# Ecodesign

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**BY**
**RIKKE DOROTHEA HUULGAARD**

DISSERTATION SUBMITTED 2015

AALBORG UNIVERSITY
DENMARK

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Dissertation submitted

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# CV

Rikke Dorothea Huulgaard obtained her Master of Science in Engineering, Environmental Management at Aalborg University in 2007. From 2007 to 2009 Rikke worked as an environmental consultant in the Department of Safety, Health and Environment at Bang & Olufsen. Rikke's career in academia began as a scientific assistant in the Department of Development and Planning at Aalborg University and in December 2010, Rikke began her PhD project at the same department.

# ENGLISH SUMMARY

This PhD thesis is about the Ecodesign Directive and how companies apply ecodesign. The topic is addressed in two parts. In the first part, the focus is on the role and ambition level of the Ecodesign Directive and its implementation in practice, and in the second part, the focus is on the companies' approach to ecodesign from a strategic and operational perspective.

Besides document and literature studies, the main methodological approach has been case studies based on interviews and document analysis. In the first part of the thesis, a case study of the implementing measure for television provides in-depth information on the achievements and ambitions of the Ecodesign Directive. In addition, a life cycle assessment of two televisions is carried out. In the second part of the thesis, the research questions are addressed through a case study of Grundfos, Bang & Olufsen (B&O) and Danfoss Power Electronics (Danfoss PE).

The analyses shows that the Ecodesign Directive provides a framework for setting comprehensive ecodesign requirements, but the implementation of the Ecodesign Directive entails a unilateral focus on energy in the use phase. The reason for the unilateral focus is the lengthy policymaking process, the initial scope of the Directive (energy-using products), and that only the most important environmental impacts are considered. The unilateral focus on energy was particularly prevalent in the early adopted implementing measures from 2009 to 2010. In the more recent implementing measures and voluntary agreements, requirements have been set up to a limited extent for other life cycle phases and environmental impact categories, for example operational motor lifetime for vacuum cleaners. Furthermore, the case study of televisions shows that the ambition of the minimum requirements is relatively low, and ecodesign efforts are driven by technological development rather than the Ecodesign Directive.

The first step in analysing companies' approach to ecodesign is to examine their sustainability strategies. A conceptual framework is developed to characterise the case companies' sustainability strategies, which differentiate between four levels of sustainability strategies. Another conceptual framework is applied to analyse the drivers and barriers of ecodesign, namely regulatory push/pull, technology push, market pull and business internal aspects. The analyses shows that Grundfos' strategic approach to sustainability primarily is on an organisational transformation and systems building level, implying a high ambition level. B&O's and Danfoss PE's sustainability strategies are primarily focused on operational optimisation, including elements of both organisational transformation and ad hoc strategies. To some degree sustainability is included in their strategies, but significant efforts are necessary in

order to more completely integrate sustainability into the daily practices around product development.

Even though the three companies have different strategies towards sustainability, the employees are facing similar challenges when working with sustainability. In all three cases, the organisational structure is not yet in line with the ambition level, the product development and the environmental support functions are separate entities with limited interaction and the initiatives to integrate environmental issues in the product development projects are often met with scepticism. Furthermore, single staff members are a driver for working with sustainability in all three companies.

Concerning the drivers and barriers of ecodesign, the analyses reveals that the companies' business strategy is a major both driver and barrier for practicing ecodesign in the companies. In the product development, the product concept specification and the product requirement specification are the main guides for the product development, and these are, therefore, determining the approach to ecodesign. Another major both driver and barrier especially regarding energy efficiency is technological development. Regarding the specific influence of the Ecodesign Directive, the Directive influences the companies, no matter at what strategic level the company is working with sustainability.

Finally, in an effort to find explanations to how companies' ecodesign efforts could be improved, Etienne Wenger's communities of practice perspective is applied as a framework for understanding examples from two case studies (B&O and an anonymous company). The analysis shows that both companies have a mature product development community, which does not effectively engage with the environmental function of the company. This entails difficulties for the integration of ecodesign activities in the product development processes. The importance of the environmental specialists' ability to act as brokers between environmental requirements, standards and the product development community is highlighted. Boundary objects are likewise important as translation tools and instruments for engaging the product development community in ecodesign activities. The analysis concludes that it is possible to strengthen ecodesign in product development through cultivating communities of practice—among other things, through making the value of participating in the community clear, and through creating familiarity in the community practices to ensure a sense of belonging, but a sense of excitement is also necessary to keep the interest of the community members.

# DANSK SAMMENFATNING

Denne PhD afhandling handler om ecodesigndirektivet og virksomheders arbejde med ecodesign. Emnet bliver behandlet i to dele. I den første del af afhandlingen fokuseres der på ecodesigndirektivets rolle og ambitioner, og hvordan det er implementeret i praksis. I anden del fokuseres der på virksomhedernes tilgang til ecodesign fra et strategisk og et operationelt perspektiv.

Ud over dokument- og litteraturstudier, er den primære metodiske tilgang case studier og herunder interviews. I første del af afhandlingen giver et case studie af ecodesignforordningen for fjernsyn en dybdegående forståelse for ecodesigndirektivets resultater og ambitioner. Derudover, præsenteres en livscyklusvurdering af to fjernsyn. I anden del af afhandlingen, bliver forskningsspørgsmålene besvaret gennem et case studie af Grundfos, Bang & Olufsen (B&O) og Danfoss Power Electronics (Danfoss PE).

Analyserne viser, at mens ecodesigndirektivet sætter rammerne for fastsættelse af omfattende ecodesign krav, så medfører implementeringen af direktivet et ensidigt fokus på energi i brugsfasen. Årsagen til dette er den langstrakte proces omkring udarbejdelse og vedtagelse af ecodesignkrav, det oprindelige anvendelsesområde (energiforbrugende produkter) og at kun de vigtigste miljøpåvirkninger bliver taget med i kravene. Det ensidige fokus på energi i brugsfasen er særligt fremherskende i de første ecodesignforordninger, som blev vedtaget i 2009-2010. I de senere ecodesignforordninger og frivillige aftaler blev der, omend i begrænset omfang, stillet krav til andre livscyklusfaser og miljøpåvirkningskategorier, for eksempel krav til motorens driftslevetid for støvsugere. Derudover viser case studiet af ecodesignforordningen for fjernsyn, at ambitionsniveauet for minimumskravene er relativt lave, og at ecodesign i praksis bliver drevet mere af den teknologiske udvikling end af ecodesigndirektivet.

Første trin i analysen af virksomhedernes arbejde med ecodesign er en analyse af deres bæredygtighedsstrategier. Hertil udvikles en begrebsramme, som opdeler virksomhedernes bæredygtighedsstrategier i fire ambitionsniveauer. Der er ligeledes udviklet en begrebsramme til at analysere drivkræfter og barrierer for ecodesign; regulering, teknologi, marked, og interne virksomhedsaspekter. Analysen viser, at Grundfos' strategiske tilgang til bæredygtighed primært fokuserer på organisatorisk transformering og systemopbygning, hvilket indikerer et højt ambitionsniveau. B&O's og Danfoss PEs bæredygtighedsstrategier fokuserer primært på driftsoptimeringer, med elementer af både organisatorisk transformering og ad hoc strategier. Dette indikerer, at de inkluderer bæredygtighed i strategierne til en vis grad, men at en væsentlig indsats er nødvendig for at integrere bæredygtighed mere fuldstændigt i den daglige praksis omkring produktudviklingen. Uanset hvilket strategisk niveau virksomheden arbejder med bæredygtighed på, oplever de ansatte samme udfordringer i deres arbejde med bæredygtighed. I alle tre virksomheder svarer de organisatoriske strukturer ikke til det strategiske ambitionsniveau, produktudviklingen og miljøfunktionen i virksomhederne er separate enheder med begrænset interaktion, og initiativer til at integrere miljøhensyn i produktudviklingsprojekter bliver ofte mødt med skepsis. Endvidere er de enkelte ansatte en væsentlig drivkraft for arbejdet med bæredygtighed i alle tre virksomheder.

Analysen viser, at virksomhedernes forretningsstrategi både er en vigtig drivkraft og barriere for at praktisere ecodesign i virksomhederne. I produktudviklingen er produktkonceptspecifikationen og produktkravspecifikationen den vigtigste retningslinje for produktudviklingen, og denne er derfor afgørende for tilgangen til ecodesign i produktudviklingen. En anden væsentlig drivkraft og barriere, særligt i forbindelse med energieffektivitet, er den teknologiske udvikling. Endelig har ecodesign direktivet en indflydelse på virksomhederne, uanset hvilken strategisk tilgang til bæredygtighed de har.

Afslutningsvis er Etienne Wengers teori om praksisfællesskaber anvendt i to case virksomheder (B&O og en anonym virksomhed) til at forstå hvorledes virksomheder kan forbedre deres arbejde med ecodesign. Analysen viser, at begge virksomheders praksisfællesskab omkring produktudviklingen er på et modent stadie, og at der ikke er en effektiv involvering af miljøfunktionerne i virksomheden. Dette medfører vanskeligheder i forhold til integrationen af ecodesign i produktudviklingsprocesserne. Analysen fremhæver ligeledes vigtigheden af miljøspecialistens evne til at fungere som mægler mellem miljøkrav og miljøstandarder på den ene side og produktudviklingspraksisfællesskabet på den anden side. Grænseobjekter er ligeledes vigtige som oversættelsesværktøj og som værktøj til at engagere produktudviklingspraksisfællesskabet i ecodesignaktiviteter. Det konkluderes, at det er muligt at styrke ecodesign i produktudviklingen gennem kultivering af praksisfællesskabet. Blandt andet ved at synliggøre værdien af at deltage i fællesskabet, og sikre et tilhørsforhold hertil ved at skabe en fortrolighed omkring det. En vis spænding er dog også nødvendig for at fastholde interessen blandt fællesskabets medlemmer.

# DEUTSCHE ZUSAMMENFASSUNG

Die Dissertation beschäftigt sich mit der Ökodesign-Richtlinie und der Arbeit von Unternehmen mit Ökodesign. Das Thema wird in zwei Teilen behandelt. Im ersten Teil liegt der Schwerpunkt auf der Rolle und dem Ambitionsniveau der Ökodesign-Richtlinie und deren Umsetzung in der Praxis. Im zweiten Teil ist die Vorgehensweise der Unternehmen zu Ökodesign aus strategischer und operativer Sicht im Fokus.

Neben Dokument- und Literaturstudien sind Fallstudien basierend auf Interviews der primäre methodische Ansatz. Im ersten Teil der Arbeit liefert eine Fallstudie über die Verordnung für TV-Geräte ein eingehendes Verständnis der Leistungen und Ambitionen der Ökodesign-Richtlinie. Darüber hinaus wird eine Ökobilanz für zwei TV-Geräte erstellt. Im zweiten Teil der Dissertation werden die Forschungsfragen mit Hilfe von Fallstudien über Grundfos, Bang & Olufsen (B&O) und Danfoss Power Electronics (Danfoss PE) beantwortet.

Die Analysen zeigen, dass die Ökodesign-Richtlinie einen Rahmen für die Festlegung umfassender Ökodesign-Anforderungen vorgibt, jedoch führt die Umsetzung der Ökodesign-Richtlinie in Verordnungen zu einer einseitigen Fokussierung auf Energie in der Nutzungsphase. Der Grund dafür ist der langwierige politische Entscheidungsprozess, der ursprüngliche Geltungsbereich der Richtlinie (energiebetriebene Produkte) und die Tatsache, dass nur die wichtigsten Umweltauswirkungen berücksichtigt werden. Die einseitige Fokussierung auf Energie ist besonders verbreitet in den ersten Verordnungen von 2009 bis 2010. In den neueren Verordnungen und freiwilligen Vereinbarungen wurden Kriterien zu anderen Lebenszyklusphasen und Umweltwirkungskategorien in begrenztem Umfang festgelegt, zum Beispiel bezüglich der Lebensdauer von Betriebsmotoren in Staubsaugern. Darüber hinaus zeigt die Fallstudie von TV-Geräten, dass das Ambitionsniveau der Mindestanforderungen relativ niedrig ist und dass Ökodesign in der Praxis mehr durch technologischen Fortschritt als durch die Ökodesign-Richtlinie angetrieben wird.

Der erste Schritt in der Analyse der Vorgehensweise der Unternehmen mit Ökodesign, ist eine Analyse der Nachhaltigkeitsstrategien der Unternehmen. Ein Rahmenkonzept, das die Nachhaltigkeitsstrategien in vier Ebenen unterteilt, wurde entwickelt, um die Nachhaltigkeitsstrategien der Unternehmen zu charakterisieren. Ein weiterer konzeptioneller Rahmen wurde entwickelt um die treibenden Kräfte und Barrieren bezüglich Ökodesign zu analysieren, nämlich Gesetzgebung, Technologie, Markt und unternehmensinterne Aspekte. Die Analysen zeigen, dass Grundfos‘ strategische Vorgehensweise zur Nachhaltigkeit sich hauptsächlich auf organisatorischen Wandel und Systemaufbau konzentriert, welches auf ein hohes

Ambitionsniveau hinweist. Die Nachhaltigkeitsstrategien von B&O und Danfoss PE konzentrieren sich vor allem auf Betriebsoptimierung, darunter sowohl Elemente des organisatorischen Wandels als auch Ad-hoc-Strategien. Dies bedeutet, dass diese beiden Unternehmen in einem gewissen Umfang Nachhaltigkeit in ihre Strategien einbezogen haben, aber dass große Anstrengungen erforderlich sind, um Nachhaltigkeit in vollem Umfang in die tägliche Praxis der Produktentwicklung zu integrieren. Auch wenn die drei Unternehmen unterschiedliche Strategien in Bezug auf Nachhaltigkeit haben, stehen die Mitarbeiter vor ähnlichen Herausforderungen bei der Arbeit mit Nachhaltigkeit. Zum Beispiel ist in allen drei Fällen die Organisationsstruktur noch nicht im Einklang mit dem Ambitionsniveau, die Produktentwicklung und die Umweltsupportfunktionen sind getrennte Einheiten mit begrenzter Interaktion und die Initiativen zur Integration von Umweltaspekten in Produktentwicklungsprojekten werden oft mit Skepsis betrachtet. Darüber hinaus sind einzelne Mitarbeiter ein Antrieb für die Arbeit mit der Nachhaltigkeit in allen drei Unternehmen.

In Bezug auf die Triebkräfte und Barrieren des Ökodesigns zeigen die Analysen, dass die Geschäftsstrategie der Unternehmen eine bedeutende Treibkraft und zugleich Barriere für das Ökodesign ist. In der Produktentwicklung, sind die Produktkonzeptspezifikation und das Pflichtenheft die wichtigste Leitlinie für die Produktentwicklung, und diese bestimmen daher den Ansatz in der Arbeit mit Ökodesign. Eine weitere bedeutende treibende Kraft und Barriere, insbesondere in Bezug auf die Energieeffizienz, ist der technologische Fortschritt. In Bezug auf den spezifischen Einfluss der Ökodesign-Richtlinie hat die Richtlinie die Unternehmen beeinflusst, unabhängig davon auf welcher Strategieebene sie mit Nachhaltigkeit arbeiten.

Abschließend wird Etienne Wengers Theorie der praxisbezogenen Gemeinschaften (communities of practice) in zwei Fallstudien (B&O und ein anonymes Unternehmen) angewendet, um zu verstehen, wie Unternehmen ihre Arbeit mit Ökodesign verbessern können. Die Analyse zeigt, dass die Praxisgemeinschaften rund um die Produktentwicklung in beiden Unternehmen sehr ausgereift sind und sich nicht effektiv mit der Umweltfunktion des Unternehmens beschäftigen. Dies führt zu Schwierigkeiten in Bezug auf die Integration von Ökodesign-Aktivitäten in den Produktentwicklungsprozess. Die Bedeutung der Fähigkeit der Umweltspezialisten als Vermittler zwischen den ökologischen Anforderungen und Standards auf der einen Seite, und der Praxisgemeinschaft in der Produktentwicklung auf der anderen Seite, zu agieren, wird in diesem Zusammenhang hervorgehoben. Grenzobjekte sind ebenfalls wichtig als Übersetzungswerkzeuge und als Instrumente, um die Praxisgemeinschaft in der Produktentwicklung an Ökodesign-Aktivitäten zu beteiligen. Die Analyse schlussfolgert, dass es möglich ist Ökodesign in der Produktentwicklung durch die Kultivierung von Praxisgemeinschaften zu stärken. Unter anderem durch Sichtbarmachung des Nutzens der Teilnahme an der Praxisgemeinschaft und durch Herbeiführung von Vertrautheit in der Praxis rund um die Gemeinschaft, um ein Gefühl der Zugehörigkeit zu schaffen. Eine gewisse Lebendigkeit ist auch notwendig, um das Interesse bei den Mitgliedern der Gemeinschaft zu erhalten.

# ACKNOWLEDGEMENTS

This thesis could not have been written without the support from a number of organisations, peers and family, and I would like to begin with a word of thanks.

First of all to my supervisors, Professor Arne Remmen and Associate Professor Carla Smink. Thank you for inspiring and challenging me, for your many, many comments on my drafts and for encouraging me to do a PhD in the first place.

This PhD research project was financed through the project *Ecodesign Requirements for Televisions* financed by the Danish Environmental Protection Agency. In Appendix B, the outcome of the project is included. The PhD research project was furthermore financed through the project *Clean Enterprises of the 21$^{st}$ Century*, which was partly financed by the European Commission LIFE+ programme. The project was a collaboration between the Confederation of Danish Industry, the Danish Environmental Protection Agency, Green Cross Denmark and Aalborg University. Thank you for an interesting and fun collaboration.

During my PhD studies, I spent 11 months at the Danish Environmental Protection Agency in Copenhagen. Here I followed the Environmental Technology Team, and I would like to thank Gert Sønderskov Hansen and everyone on the team for giving me the opportunity to visit.

Special thanks to the three case companies, Grundfos, Bang & Olufsen and Danfoss Power Electronics, in particular, Mogens Meyer, Lone Nielsen, Jesper Gregersen and Bruno Lund Pedersen. Thank you for opening your company gates to me, for answering my endless lists of questions and allowing me to get an insight into your organisation. It is without doubt that collaborations like these make research exciting and worthwhile.

Last but not least, to my dear friends and family—particularly my parents, my husband and my son—thank you for supporting me and believing in me during tough times and for laughing and celebrating with me during good times. I could not have done this without you.

Aalborg, December 2015

Rikke Dorothea Huulgaard

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# CHAPTER 1. INTRODUCTION

My interest in the environment began early. As a child it was an innocent interest in flowers, gardens and later forestry. Gradually, and especially during my time at Aalborg University, I realised the extent of environmental problems in the world, how complex the society really is and, thereby, also the complexity of any solution to the environmental problems. Today, what fascinates me is the dynamic between companies, authorities and consumers, and how the interplay among them can move society towards a sustainable development. All three groups play significant roles as part of the problem, but also the solution. The responsibility of the authorities is to create the right conditions, incentives and restrictions for both companies and consumers to act environmentally responsible. The companies have great potential to influence not only the environmental impacts of their own activities but also the actions of consumers through the products they place on the market and to influence the policy making processes. Likewise, consumers have the possibility to influence the environmental actions of companies through traditional demand dynamics, just as through utilising their voting rights or through joining NGOs they are able to influence actions of the governments.

Companies' first approach to dealing with environmental challenges began in the 1960s and was focused on abatement, such as dilution and end-of-pipe technologies (Remmen, 2001). Although, some companies today still lean on these abatement technologies, gradually, as these technologies have proved insufficient, more preventive approaches have been explored. The different preventive approaches to addressing the environmental challenges and, for that matter, the environmental approach of the authorities as well, has been described as a four step ladder (see Figure 1).

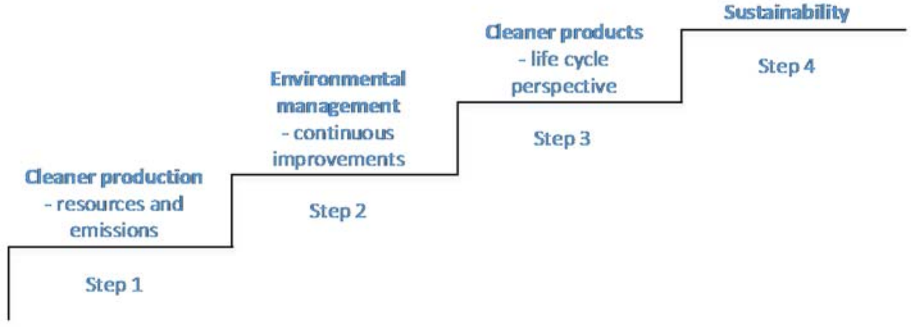


*Figure 1: Different approaches to preventive environmental efforts (Remmen & Münster, 2002; Remmen, Dirckinck-Holmfeld & Nielsen, 2015)*

In the first step, the focus is directed towards the companies' own production sites, e.g. on substituting hazardous substances and on reductions of pollution and emissions. In step two, the focus is broadened to the entire organisation, and continuous improvements of environmental performance are required. The third step involves the entire product chain from suppliers to customers, and aspects in the entire product life cycle should be considered, from extraction of raw materials, development and production of the product, sales, marketing, distribution, use phase and when the product is discarded or recycled. The fourth step is sustainability. From the companies' perspective, sustainability requires that equal attention be given to the triple bottom line, i.e. the traditional economic aspects, the environmental as well as the social aspects (Elkington, 1997). The development in public environmental regulation has followed the same steps, and this is described more in detail in Part I, especially related to step three and policies to promote cleaner products.

The focus of this thesis is on one of the EU initiatives, The Ecodesign Directive, which pertains to step 3 in Figure 1. The Ecodesign Directive is presented in detail and analysed in Part I of the thesis, but for now it is relevant to highlight that the Ecodesign Directive is an example of the interesting dynamic between the authorities, companies and consumers, aimed at moving towards a sustainable development. The aim of the Directive is to provide a framework for the companies to environmentally improve their products, and thereby improve the environmental performance of the products available for consumers. The importance of focusing on the products becomes obvious when discussing topics such as the amounts of plastic waste in the oceans, hazardous substances and chemicals in products, the use of conflict minerals in electronic devices, the energy and resource consumption or the increasing amounts of products in our homes (Jambeck et al, 2015; Hansen, Nielsen & Vium, 2014; Schüler et al, 2011; Dittrich et al, 2012).

Never before have we in the industrialised world had as many products and appliances in our homes as we have today. The quantity, variety and the complexity of the products are increasing. According to figures from the Danish Energy Agency the number of appliances in Danish households has increased significantly (see Figure 2). As an example, the number of microwave ovens has grown 428% in the period 1990 to 2013, and the number of tumble driers and dishwashers has grown 187% and 235%, respectively, in the same period. For televisions, the number has grown from approximately one television per household in 1990 to approximately one television per person in 2010, when the numbers peaked (The Danish Energy Agency, 2015). The sales peak for televisions in 2010 is in line with the average sales in the EU. It is not definite what results in this peak, but topten.eu estimates that it is due to the switch to digital television, and possibly also a wish amongst the consumers to profit from the opportunities of the new technology available, such as high definition and slimmer flat panel displays (Michel, Attali & Bush, 2014).

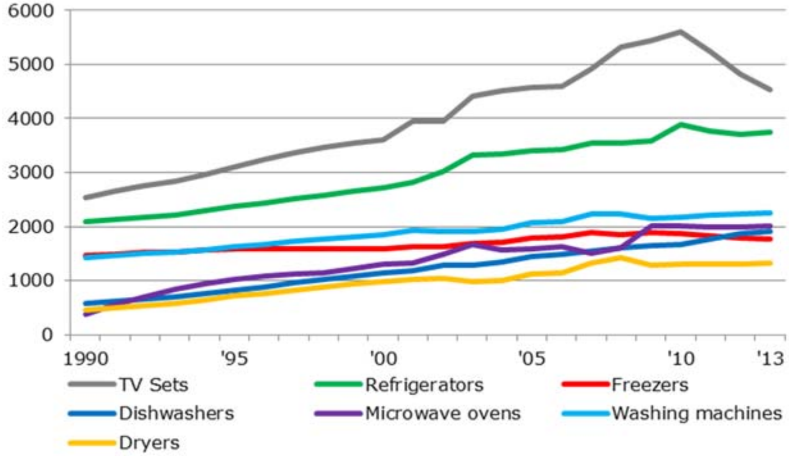


*Figure 2: Household stock of electrical appliances in Denmark (in 1000 units) (The Danish Energy Agency, 2015).*

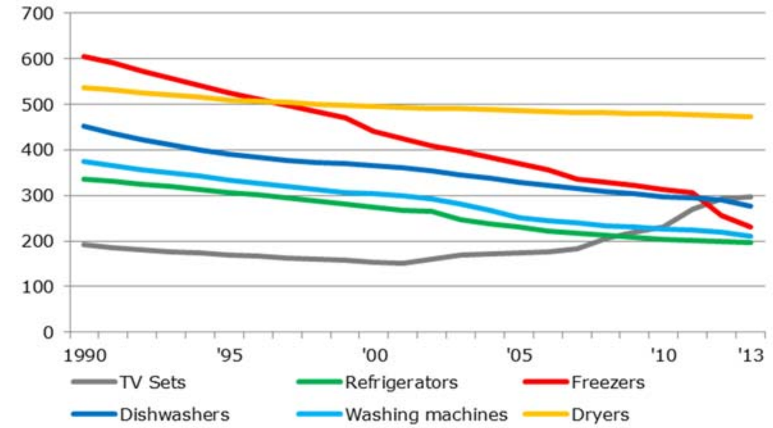


*Figure 3: Specific electricity consumption of household appliances (in kWh/year) (The Danish Energy Agency, 2015).*

A positive development is, however, that generally, the energy consumption of the specific products is reduced (see Figure 3). The observant reader has noticed that the energy consumption of televisions, in contrast to the other product groups illustrated, had an increasing energy consumption per product since 2000. This development must be seen in relation to the development in the television sales, where there has been an on-going trend towards consumers buying televisions with larger screen sizes

(Michel, Attali & Bush, 2014). In the period 2007–2013, the average screen size sold increased from 31.6” to 38.9”, and in Figure 4, it is illustrated that the most popular screen size sold has increased from 30” to 40” in 2007 to 40” to 50” in 2013 (Michel, Attali & Bush, 2014). This trend is not unique for Denmark, although the trend here is stronger than the EU average. The average screen size sold in the EU has increased from 29.3” in 2007 to 35” in 2013, and the most popular screen size has continuously been in the range 30”–40”, but the percentage of larger screen sizes has increased in the same period (Michel, Attali & Bush, 2014).

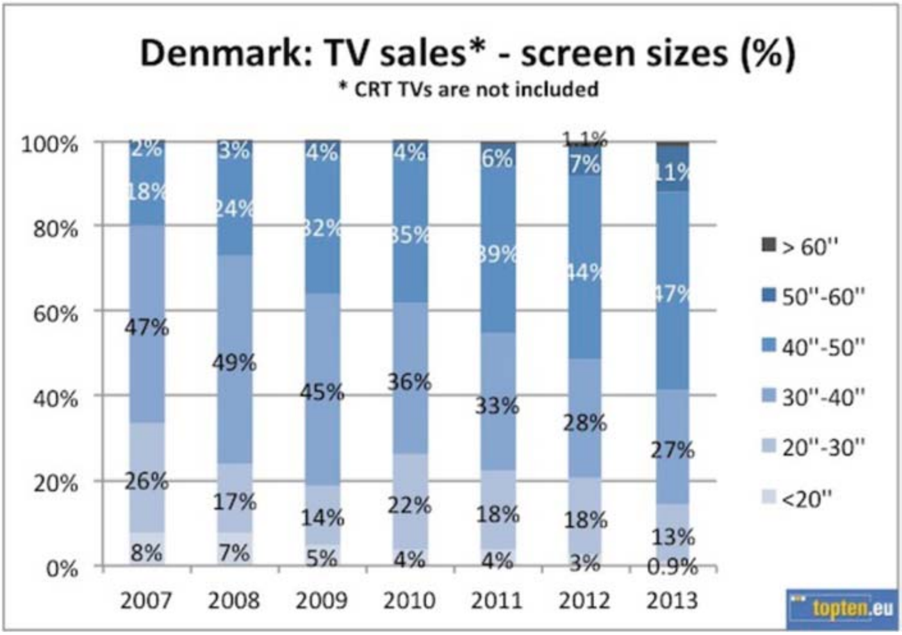


*Figure 4: Percentage of different screen size categories, based on TV sales in Denmark (Michel, Attali & Bush, 2014)*

In addition to the increasing number of products in our households, the lifespan of the individual products is decreasing (see Figure 5). The worst-case example in Figure 5 is the product category ‘small consumer electronics and accessories’, for which the median lifespan is reduced from 9.4 years in 2000 to 7.8 years in 2005. This equals a 20% reduction. The reduced lifespan implies that the pace in which we replace and discard our products is increasing and it poses an increasing environmental problem, in terms of what happens with the products when discarded and where we get the resources for producing the growing amounts of products. In the EU, the Commission responded to these trends with developing, among others, the Integrated Product Policy Approach (IPP), which specifically targets the environmental impacts of products (European Commission, 2001), and a range of directives and regulations have since been adopted targeting the different environmental aspects related to products. Examples are the RoHS Directive concerning the restriction of certain hazardous substances, the WEEEE Directive, targeting the waste from electronic and electrical products, and the Ecodesign Directive. These Directives and their interplay are analysed in Part I of this thesis.

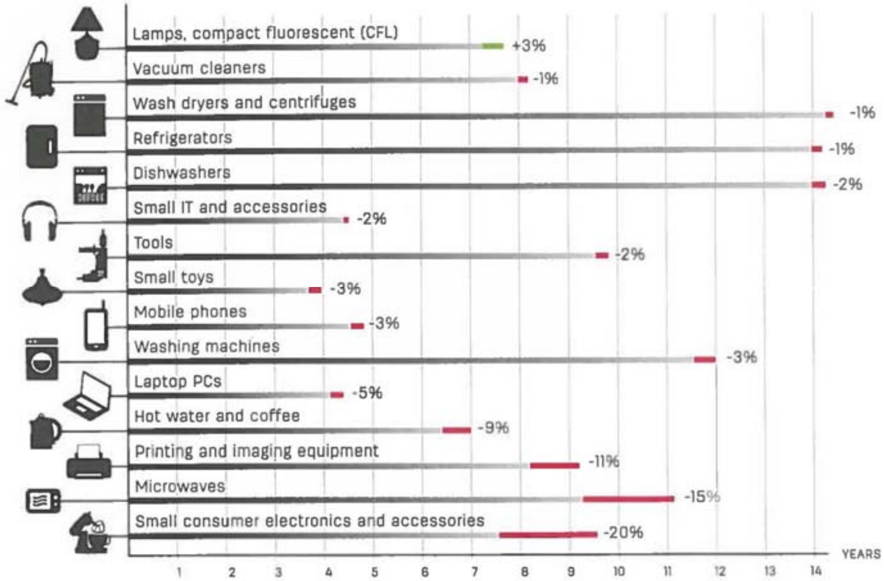


*Figure 5: The median lifespan of household products, and change over time (2000–2005) (Bakker et al, 2014)*

When the Ecodesign Directive was proposed, it was one of the first legislations of its type with the specific aim of encouraging ecodesign practices and life cycle thinking in companies. Despite the promising aim, the Directive was already in the early stages, criticised, for among other things, not being able to drive innovation among market leaders and for favouring the economic development and free movement of goods over environmental considerations despite the fact that life cycle thinking permeates the Directive (Misonne, 2005; van Rossem & Dalhammar, 2004). I was first introduced to the Directive during my studies at Aalborg University. At this point in time, the Directive was adopted but implementing measures[1] had not been finalised. My master thesis concerned how the Directive would create incentives for improving the product-related environmental performance at Bang & Olufsen (B&O), based on the draft implementing measures for televisions, personal computers and computer monitors, and also battery chargers and external power

[1] Implementing measures are separately adopted regulations laying down ecodesign requirements for defined products or environmental aspects thereof, and through which the Ecodesign Directive is implemented. (European Commission, 2009).

supplies. The research showed indications of the Directive and its implementing measures not being able to create much incentive for improving the product related environmental performance at B&O (Brunø, Thiesen & Andersen, 2007).

Later, during my employment in the Department of Safety, Health and Environment at B&O, I experienced first-hand the tentative beginnings of the implementation of the requirements. I learned to understand the dynamics and complexities in a company and in product development processes in particular. I learned the number of stakeholders involved and the many different agendas and goals that influence the processes. I understood that even though companies in theory have the opportunity to influence both consumer behaviour and authorities, smaller companies especially are also dependent on their suppliers—as these in the end determine what parts are available—and on the trade associations, through which lobbying activities often are organised. At that time, the influence of the Ecodesign Directive was limited to energy issues and other environmental issues, plus, few information requirements were included.

My experiences piqued my curiosity as to what role the Ecodesign Directive and its implementing measures actually play in promoting sustainable products and as to why companies work with ecodesign issues in the first place. Hence, the basis for this PhD thesis was given. In the following chapter, the structure of the thesis and my methodological approach are presented.

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# CHAPTER 2. METHODOLOGY

The research design, theoretical approach and data collection methods of this PhD thesis are presented in this chapter.

Following the Introduction in Chapter 1 and this methodology chapter, the thesis consists of two separate, but interlinked parts. Part I focuses on the Ecodesign Directive and on the ambitions and achievements of the Directive. This is analysed first on an overall level focusing on the concept of ecodesign, on the Ecodesign Directive's interplay with other policy instruments and on how the Directive is implemented in practice. Secondly, a product-specific approach was taken in order to analyse the ambitions and achievements of the Directive more in depth through a case study of the implementing measure for televisions, and its specific influence on the televisions on the market.

Having analysed the gap between the ambitions of the Ecodesign Directive and its achievements, Part II of the thesis focuses on how the companies address ecodesign. The case study of the implementing measure for televisions showed that eco-innovations were driven more by technological developments than the Ecodesign Directive, and Part II focuses on what the drivers and barriers for working with ecodesign in companies are, including what the actual impact of the Ecodesign Directive is in companies. This is analysed through a case study of three different Danish companies.

In Figure 6 and Figure 7, the structure of the thesis and the research questions guiding the analyses in each chapter are presented. Furthermore, Part I and Part II are each initiated by an outline of the chapters and the appertaining research questions. In the following section, the research design and theoretical approach for Part I and Part II are elaborated further.

**PART I: The Ecodesign Directive**

Chapter 3 **The Ecodesign Directive – Ambitions and Practice**

*What is the role and ambition of the Ecodesign Directive and how is it implemented in practice?*

| Role: | Ambition: | Practice: |
|---|---|---|
| • The Ecodesign Directive in a historical context<br>• Dynamics of the Ecodesign Directive and its interplay with other policy instruments | • The definition of ecodesign in theory compared to the interpretation of ecodesign in the Directive<br>• Dynamics of the Ecodesign Directive and its interplay with other policy instruments | • The definition of ecodesign in theory compared to the interpretation of ecodesign in the implementing measures<br>• The requirement level in the implementing measures<br>• The interplay between different policy instruments concerning product life cycle phases and environmental impact categories<br>• The recent attempts to include resource efficiency requirements |

Chapter 4 **A Case Study of the Implementing Measures for Televisions**

*What are the achievements and ambition of the Ecodesign Directive, based on the implementing measure for televisions?*

| Ambition: | Achievements: |
|---|---|
| • Comparison of the requirements in the preparatory study and the implementing measures<br>• The differences, similarities and interplay between the implementing measure and the different eco- and energy labels | • Performance of the televisions on the market compared to the requirements in the implementing measures and eco- and energy labels |

Chapter 5 **Article: Ecodesign Requirements for Televisions – is Energy Consumption in the Use Phase the only relevant Requirement?**

*What life cycle phases and environmental impact categories are important when setting ecodesign requirements for televisions?*

- Consequential LCA of two televisions
- Assessment of which environmental impact categories are important

Chapter 6 **Conclusion Part I**

*Figure 6: Structure of Part I of the PhD thesis.*

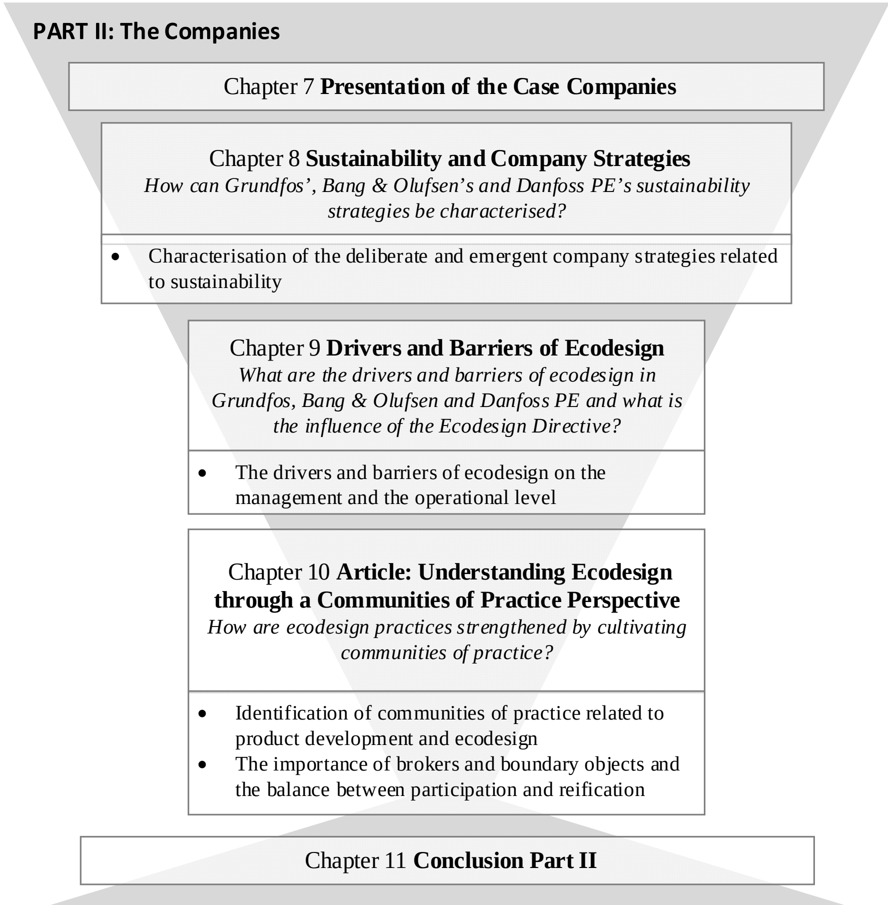


*Figure 7: Structure of Part II of the PhD thesis.*

## 2.1. RESEARCH DESIGN AND THEORETICAL APPROACH

### 2.1.1. PART I

The research design for Part I is a two-step approach to the analyses of the Ecodesign Directive. First, in Chapter 3, the Ecodesign Directive is analysed on an overall level and second, in Chapter 4 and 5, the implementing measure for televisions is analysed in depth.

The aim of the overall analysis of the Ecodesign Directive in Chapter 3 is to answer the research question: *What is the role and ambition of the Ecodesign Directive and* *how is it implemented in practice?* The approach is, therefore, first, to establish an understanding of the concept of ecodesign, which is used in the analysis of the ambition of the Directive in terms of how the interpretation of ecodesign in the Directive compares to the understanding in the literature. Next, in order to understand the role of the Directive in a policy context, the historical context of the Ecodesign Directive is analysed, i.e. the history of environmental regulation and the emergence of ecodesign in regulation. Finally, the dynamics of the Ecodesign Directive itself and the interplay with other policy instruments, such as the WEEE and RoHS Directives, and the European Ecolabel and Energy Label, are analysed to understand the role and ambition of the Ecodesign Directive in a policy context.

The implementation in practice of the Directive is analysed on a general level through examining the interpretation of the concept of ecodesign in the adopted implementing measures, through evaluating the requirement level in the adopted implementing measures. Furthermore, the interplay between the different policy instruments concerning the product life cycle phases, environmental impact categories that the different instruments include are analysed, and the recent attempts to include resource efficiency requirements in the implementing measures are explored. For an overview of the steps of the analysis, see Figure 6.

The second step of the analysis of the Ecodesign Directive is a case study of the implementing measure for televisions in Chapter 4, and the aim is to answer the research question: *What are the achievements and ambition of the Ecodesign Directive, based on a case study of the implementing measure for televisions?* Through analysing the implementing measure for televisions, an understanding of the influence of the implementing measure on a specific product and technology is achieved.

The implementing measure for televisions was chosen specifically as I, due to my former employment (see section 2.1.2), in advance, had knowledge of the technical and regulatory aspects of televisions. This was assessed as valuable in order to understand the implementing measure in detail, as these are highly technical. The aim of the analysis is to understand the achievements and ambitions of the Ecodesign Directive based on the implementing measure for televisions. The steps in analysing the ambition of the implementing measure for television is first to analyse the process from the launch of the preparatory study to the adoption of the implementing measure, and then to compare the recommended requirements in the preparatory study to the requirements in the implementing measure. Furthermore, the ambition of the implementing measure is analysed and compared with attention to differences, similarities and interplay between the implementing measure and the different eco- and energy labels. The achievements of the implementing measure are analysed through the performance of the televisions on the market, and comparing this to the requirements of the implementing measures and the different eco- and energy labels. For an overview of the steps of the analysis, see Figure 6.

In Chapter 5, the analysis of the implementing measure for televisions is taken one-step deeper. The aim is to answer the research question: *What life cycle phases and environmental impact categories are important when setting ecodesign requirements for televisions?* The ecodesign requirements in the implementing measure have been set up following a specific methodology and based on a life cycle assessment of two televisions; the analysis examines whether the results of the methodology for setting ecodesign requirements for energy-using products are correct in stating that the most important impact is energy consumption in the use phase.

The specific data collection methods are presented in section 2.2. The televisions in the analyses in Chapter 4 were chosen randomly, whereas the televisions in the article in Chapter 5 were selected in collaboration with the manufacturers, based on the assessment that these televisions specifically are representative of the manufacturer's collection of televisions in terms of sales figures and technology.

### 2.1.2. PART II

Part II focuses on the companies, including what makes companies work with ecodesign and the specific influence of the Ecodesign Directive on the companies. The analysis is based on a case study of three Danish companies, Grundfos, Bang & Olufsen (B&O) and Danfoss Power Electronics (Danfoss PE), and consists of three steps. In Chapters 8 and 9 the companies' approach to ecodesign is addressed from a strategic and practice perspective, respectively, and in Chapter 10, a proactive approach is taken as to how companies' ecodesign efforts can be strengthened.

The analysis of the case companies in Chapters 8 and 9 was divided into several levels, which can be illustrated in the matrix, explained below (see Table 1).

*Table 1: The levels of analysis of the three case companies in Chapter 8 and 9.*

| | **Management level** | **Operational level** |
|---|---|---|
| **Strategy perspective (Chapter 8)** | Deliberate strategies | Emergent strategies |
| **Practice perspective (Chapter 9)** | Drivers and barriers for including sustainability/ecodesign in the strategies | Drivers and barriers for working with ecodesign in practice in the product development process |

In Chapter 8, the focus is on the strategies, which the case companies have applied in their work with sustainability, and the aim is to answer the research question: *How can Grundfos', Bang & Olufsen's and Danfoss Power Electronics' sustainability strategies be characterised?* The strategy analysis is the first step, as the company strategies are the foundation of the companies' goals and activities. The strategy analysis is divided in two: the deliberate and the emergent strategies (see Table 1). The deliberate strategies are the planned, written strategies, monitored and controlled from beginning to finish; I particularly analysed the strategies, which were publicly available or were handed to me by the interviewees. The emergent strategies have no specific objective, and are a result of a consistent pattern of behaviour. Through analysing the emergent strategies, the aim is to investigate how the actual practices align with the deliberate strategies, and these are analysed through interviews with people across different departments in the companies. In order to analyse the strategies, a conceptual framework for characterising the companies strategies was developed based on four different frameworks, each representing partly different perspectives on companies and sustainability. The framework was used as a tool in developing the interview guides, in terms of which areas should be discussed, and it functioned as a search tool in the analysis of both documents and interviews. For an overview of Part II, see Figure 7.

In Chapter 9, focus is directed towards the practices in the companies, and the aim is to answer the research question: *What are the drivers and barriers of ecodesign in Grundfos, Bang & Olufsen and Danfoss Power Electronics, and what is the influence of the Ecodesign Directive?* The analysis is divided according to the management and the operational level (see Table 1). The management level is defined as, where policies and strategies are developed, and the operational level is defined as the ones who implement the strategies in practice. By distinguishing between these two levels the aim is to analyse both the overall sustainability strategies and ambitions of the company (at management level) and how these are implemented in practice, especially in the product development and environmental departments (at operational level). The analysis is based on interviews with people across different functions in the company, in order to obtain information on the development of strategies related to sustainability, on the product development processes and on how environmental considerations are integrated in the product development. In order to analyse the drivers and barriers of ecodesign, a conceptual framework illustrating the determinants of eco-innovation was used for both the data gathering process and the presentation of the findings. The framework is useful for illustrating the drivers and barriers of ecodesign too, as eco-innovation and ecodesign are comparable to some degree. For an overview of Part II, see Figure 7.

In Chapter 10, the practice perspective is analysed one step deeper with the aim of answering the research question: *How are ecodesign practices strengthened by cultivating communities of practice?* The theoretical approach in the chapter is Etienne Wenger's communities of practice, which is applied to the existing environmental and product development practices of two Danish case companies, B&O and an anonymous company. The analysis, among other things, focuses on the environmental specialists' abilities to act as brokers and the importance of boundary objects in the improvement of the companies' ecodesign efforts. For an overview of Part II, see Figure 7.

The research in Part II focusing on the ecodesign approach of companies is also designed as a case study. This qualitative approach is chosen since case studies are empirically rich with information due to the use of many different sources and types of sources, and in this way, it is possible to triangulate the results. A multiple case study was chosen and the aim is to find cases that each describe something unique and are rich with information. According to Flyvbjerg (2006) the strategy for selecting cases should in such situations be information-oriented selection, since the aim is to maximise the utility of information from small samples and single cases, and the cases are selected on the expectations about their information content. In Flyvbjergs (2006) classification, there are four types of information-oriented selection. These are extreme/deviant cases, maximum variation cases, critical cases and paradigmatic cases. Neergaard (2007) adds intensity cases as a relevant strategy for selecting cases, which is describing something unique (see Table 2).

*Table 2: Strategies for information oriented selection of cases (Flyvbjerg 2006; Neergaard 2007).*

| Type of selection | Purpose |
|---|---|
| Extreme/deviant cases | To obtain information on unusual cases, which can be especially problematic or especially good in a more closely defined sense. |
| Maximum variation cases | To obtain information about the significance of various circumstances for case process and outcome (e.g. three to four cases that are different in one dimension: size, form of organisation, location, and budget). |
| Critical cases | To achieve information that permits logical deductions of the type, 'if this is (not) valid for this case, then it applies to all (no) cases'. |
| Paradigmatic cases | To develop a metaphor or establish a school for the domain that the case concerns. |
| Intensity cases | The logic in intensity cases is the same as in extreme cases, but the focus is less on the extreme and more on how the case distinguishes itself in a certain area and provides sufficient information. |

When studying several cases, the selection is maximum variation, where the aim is to select cases that capture a common topic but with a high degree of variation in participants. However, maximum variation cases require that the cases will be exposed to the same impact. (Neergaard, 2007) For the cases in this thesis, exposure to the same impact would require that they be covered by the same implementing measure, which is not the situation. The cases in this thesis were selected based on the intensity case selection strategy. The aim was to find companies that perceive the influence of the Ecodesign Directive differently and have different options for responding to the influence of the Ecodesign Directive. The criteria for selecting case companies were, therefore:

- The companies should be covered by an implementing measure
- One company representing a frontrunner company
- One company representing a company, whose environmental approach is mainly driven by legislative demands, and therefore, is less ambitious than a frontrunner company

- One company representing a company that is not directly covered by an implementing measure but through being a supplier

The first company selected was Grundfos, representing a frontrunner company. The company has a long history off focusing on energy efficient pump solutions and has been active in influencing the legislative process concerning the Energy Label. The second company selected was B&O, representing a company whose environmental approach is mainly driven by legislative demands. B&O is well known for its high-end quality and design products, but has taken the standpoint that environmental issues are not an area for differentiating their products. B&O’s activities related to product environment are, therefore, mainly driven by legislative demands. Danfoss PE was selected to include the perspective of a supplier to a company covered by an implementing measure. Danfoss PE is indirectly covered by the implementing measure for electric motors in that they produce variable speed drives, which can be used by producers of electric motors so they can be in compliance with the implementing measure.

Intensity case selection requires a great deal of preceding knowledge about the company in order to be able to assess if the company is an intensity case (Neergaard, 2007). This preceding knowledge was obtained in the case of Grundfos through the long history of collaboration between Grundfos and Aalborg University on different research projects. A vast amount of research, therefore, exists, which emphasises Grundfos’ position as a frontrunner company with respect to energy efficient solutions and their influence on the policy making processes (Holgaard, 2003; Thiesen & Remmen, 2008; Myrdal, 2010). B&O was selected as a case based on the experience and knowledge I have gained through B&O being the case company in my master’s thesis (Brunø, Thiesen, & Andersen, 2007) and through my employment in the Safety, Health and Environment Department. The topic of the master’s thesis was how the Ecodesign Directive would create incentives for improving the product-related environmental performance at B&O. An extensive analysis was, therefore, conducted regarding the product development process, and the research included interviews with various employees involved in the product development process, for example, project managers, product managers and designers. This pre-understanding and knowledge of the company has influenced the data collection (see section 2.2.4). In the following section, the data collection methods for Part I and II are presented.

## 2.2. DATA COLLECTION METHODS

The data collection methods used in this thesis are mainly qualitative. In the following section, the different methods are presented.

### 2.2.1. DOCUMENT ANALYSES

The main data collection method in Part I of this thesis was a document analysis of legislative texts and criteria documents. Strategy and action plan documents from the EU were also analysed in order to follow the development in the political agenda of the EU. In Chapter 4, the information on the energy consumption of the televisions was found on the homepages of the producers and in their product catalogues.

In Part II, document analysis was mainly used in the presentation of the companies and in the analysis of the company strategies. The documents analysed covered the annual reports, strategy and policy documents and the homepages of the companies.

### 2.2.2. LITERATURE STUDIES

Literature studies were used to provide a theoretical background and understanding of the analyses. In Part I, literature on the development in public environmental regulation, types of policy instruments and on ecodesign was analysed.

In Part II of this thesis, an extensive literature review was conducted on company strategies related to sustainability. The second extensive literature review in Part II concerned the drivers and barriers of ecodesign and eco-innovation. Finally, in the paper in Chapter 10, a literature study was conducted related to the communities of practice theory.

### 2.2.3. CONFERENCES AND WORKSHOPS

During the PhD process, I attended several conferences (see Table 3). The conferences provided valuable insights into recent developments within, for example, policy and regulation, technology development (particularly pumps and televisions), and generally gave an understanding of what topics are on the agenda of the different stakeholders, be it authorities, companies or NGOs. On three occasions in the first 1.5 years of the PhD study, I presented three papers about the Ecodesign Directive at different conferences (see Appendix C), and I received valuable comments on these papers. These specific comments helped shape my understanding of how the Ecodesign Directive is perceived by other stakeholders. Furthermore, the conferences provided an opportunity to observe and converse with people involved in working with the Ecodesign Directive.

What struck me the most at these conferences were the strong and disparate opinions of the different stakeholders. The papers I presented at the conferences represented my initial scepticism as to the ability of the Ecodesign Directive to actually drive ecodesign in the companies due to the unilateral focus in the requirements on energy and the low ambition level of the requirements. The people involved with establishing the requirements were firm in their belief that the Directive and its implementing measures were working well and that their objective was correct in only setting up requirements for the most important environmental impacts. One concern was that it would be far too complicated and take too much time to expand the requirements to include other aspects besides energy.

The comments from the industry were mainly negative, for instance, concerning SMEs who do not have enough buying power to influence the suppliers and their development of greener parts. Another example was the correlation between functions, such as picture quality, and energy consumption. The industry, therefore, argued that it was not enough just to look at energy consumption, but other aspects should be taken into consideration as well in order to keep or improve the functionality and quality of the products. However, after one of my presentations at a conference in Vienna, a man from Philips approached me, who was more favourably disposed towards my presentation. He suggested that I look into the televisions from Philips, as they were highly energy efficient and could easily comply with the requirements in the implementing measures. Finally, the NGOs I talked to at the conference completely agreed with my conclusions that the focus of the Directive and the implementing measures were too unilateral and not ambitious enough.

*Table 3: List of conferences and workshops attended during the PhD study.*

| Conference | Organiser | Date |
|---|---|---|
| European Roundtable on Sustainable Consumption and production conference and the 6th Environmental Management for Sustainable Universities conference | The Hague University of Applied Sciences, Delft University of Technology and TNO | Delft, October 2010 |
| Going Green: CARE Innovation | CARE Electronics | Vienna, November 2010 |
| Workshop on Ecodesign and Resource Efficiency | Aalborg University, Danish Ministry of the Environment and Lund University | Copenhagen, November 2010 |
| Energy Efficiency in Domestic Appliances and Lighting | Danish Energy Association | Copenhagen, May 2011 |
| Roundtable on Eco-design | EUROPUMP, the European Pump Manufacturers Association | Brussels, October 2011 |
| Workshop on Green Business Model Innovation | The OECD, European Commission, and Nordic Innovation | Copenhagen, January 2012 |
| Circular Economy: Saving resources, creating jobs; Green Week | European Commission | Brussels, June 2014 |
| Ecodesign as a Tool for Resource Efficiency and Circular Economy | Nordic Council of Ministers | Brussels, June 2014 |

### 2.2.4. INTERVIEWS

The analyses of the case companies in Part II were, besides document analyses, based on interviews. In Table 4, an overview of the interviewees is provided, and in Appendix A, details about the interviews are provided along with an example of the interview guide.

*Table 4: Overview of the interviews conducted for this PhD thesis.*

| | **Management level** | **Operational level** |
|---|---|---|
| Grundfos | 4 interviews | 12 interviews |
| Bang & Olufsen | 5 interviews | 4 interviews |
| Danfoss Power Electronics | 3 interviews | 6 interviews |

All interviews were conducted as semi-structured interviews. The interview guides were based on the conceptual framework for characterising the companies' sustainability strategies in Chapter 8, and on the conceptual framework of drivers and barriers of ecodesign in Chapter 9. An example of the interview guide is given in Appendix A. All interviews were recorded and later transcribed, except in one case at B&O and two cases at Danfoss PE, when I was given a tour at the companies.

At Grundfos, it proved difficult to get interviews with management level responsible for developing the company strategies. Hence, the majority of the interviewees relate to the operational level (see Table 4). The case study of B&O was chosen mainly to interview persons on the management level. The reason was my preunderstanding and knowledge of the company, especially on the operational level, due to my earlier research at the company and my former employment. To ensure the validity of the information concerning the operational level, the environmental consultant was interviewed specifically about the changes in the company, company procedures and culture. For the one case where significant changes had happened, the senior manager of R&D was interviewed.

All interviews except two at B&O are conducted in 2012 and early 2013. This means that the analyses of the companies are representative for this period in time, and as such, it is possible that changes in, for example, company structures, culture and product portfolio have taken place.

### 2.2.5. LIFE CYCLE ASSESSMENT

The paper presented in Chapter 5 is based on a life cycle assessment, and it is the only quantitative method applied in this thesis. The details on the life cycle assessment methodology are given in the paper. All information on the televisions analysed was either provided in Excel spreadsheets by the company or collected at the company by the authors of the paper.

## 2.3. REFLECTIONS

Before reflecting on the validity and reliability of the study, attention should be given to a factor that has influenced the analyses of this thesis. This factor is time. Initially, the research in Part I of the thesis resulted in scepticism about the ability of the Ecodesign Directive to actually drive ecodesign in the companies. However, due to two periods of leave of absence, the PhD study was extended by two years. In the meantime, significant changes took place in the implementation of the Ecodesign Directive. The Ecodesign Directive and its implementing measures had been evaluated twice, and the implementing measure, the Energy Label, the European Ecolabel and the Nordic Ecolabel for televisions either were or are currently under revision. An update of the analysis in Part I was, therefore, necessary. Interestingly, it turned out that many of the points of criticism raised in the initial analysis in Part I were also realised by the policy makers in the EU and are now being revised accordingly. Had the PhD study not been extended and had the initial analysis in Part I resulted in a less sceptical position towards the Ecodesign Directive’s ability to drive ecodesign in the companies, which was the case after the analysis in Part I was updated, the research approach might have been different. Reflections on this are presented in the conclusions of Part I in Chapter 6.

Two techniques are applied to ensure the internal validity, or credibility, which is the term often used in qualitative research. These are respondent validation, which is a process and triangulation. Respondent validation is when the researcher seeks corroboration though providing the people whom she has conducted research with an account of her findings. (Bryman, 2012) Both papers (Chapters 5 and 10) and the analyses of the three case companies in Part II were sent to the companies for validation and quality assurance. On the same occasion, the companies were asked to comment if any significant changes had occurred since the interviews were conducted. Only one company responded with comments on that, and these are included as an addendum to the company presentation in Chapter 7. The triangulation technique, where multiple sources of data are used to study the same phenomenon, was applied as far as possible in all three case companies. However, due to the varying number of interviews at the three companies, the value of the technique is highest in the Grundfos case.

External validity or transferability is concerned with whether the results of the study can be generalised. According to Flyvbjerg (2006), it is possible to generalise results of a single case study when carefully selecting the cases. Critical cases are especially relevant for generalisations of the type, ‘if it is (not) valid for this case, then it applies to all (no) cases’ (Flyvbjerg. 2006). The case selection for this thesis was based on intensity selection, but cases that distinguished themselves in different ways were sought. Grundfos was selected as the frontrunner and B&O was selected as the less ambitious company. The Grundfos would also qualify as a critical case, as they have been the driving forces together with their business association in pushing, first, for the voluntary Energy Label for pumps, and now, for the requirements in the implementing measures. B&O, on the other hand, does not qualify as a critical case of an less ambitious company, as they are too organised and formalised in their environmental work to qualify as a critical case.

Reliability, or dependability, is concerned with the results of the study that can be repeated. In qualitative research, dependability should be ensured by keeping the records from the entire research process, including, for instance, fieldwork notes and interview transcriptions. It is then up to the readers to assess whether the study would apply to other contexts (Bryman, 2012). For this thesis, all such records are kept; however, in social sciences, changes are always on-going both internally and in the context, and due to the time factor, even though the same interview guides were used to interview the same people, the answers most likely would be different, as they reflect the current moment in time.

## 2.4. REFERENCES CHAPTER 2

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# PART I – THE ECODESIGN DIRECTIVE

The Ecodesign Directive is the focus of this first part of the thesis. The aim is to understand the context in which the Ecodesign Directive was developed and adopted, and to understand what the ambitions and achievements of the Directive are. The analysis of the Ecodesign Directive is divided in three steps, starting with an analysis of the Ecodesign Directive on an overall level, followed by a case study of the implementing measure for television, which is divided into an analysis of the requirements in the implementing measure and a life cycle assessment of two televisions. In the following, the research questions that guide the analyses are presented along with the structure of Part I.

## 2.5. RESEARCH QUESTIONS AND STRUCTURE OF PART I

**Chapter 3 The Ecodesign Directive: Ambitions and Practice** concerns the Ecodesign Directive on an overall level. The chapter begins with a theoretical discussion of the definition of ecodesign and a review of the historical development of public environmental regulation. The ambition of the Directive and how the Directive is implemented in practice is analysed through comparing how the concept of ecodesign is defined in theory and how ecodesign is defined in the Directive, and in the interpretation of the concept of ecodesign in the implementing measures, and also through focusing on the interplay between the Ecodesign Directive and other policy instruments. The research question guiding the analyses is:

*What is the role and ambition of the Ecodesign Directive and how is it implemented in practice?*

**Chapter 4 A Case Study of the Implementing Measure for Televisions** takes the analysis of the Ecodesign Directive one step deeper in that it features a case study of the implementing measure for televisions, which is the regulation in which the ecodesign requirements for televisions are laid out. The point of departure of the analysis is an analysis of the implementing measure for televisions conducted in 2009–2011. However, since then, quite a few changes have taken place both on the general political agenda in the EU, concerning the technological development of televisions, and the requirements in force or under revision. The conclusions of the 2009–2011 analysis are therefore supplemented with updated information. The research question guiding the analysis is:

*What are the achievements and ambitions of the Ecodesign Directive, based on the implementing measure for televisions?*

**Chapter 5 Paper: Ecodesign Requirements for Televisions: Is Energy Consumption in the Use Phase the Only Relevant Requirement?** A life cycle assessment of two televisions conducted in 2010 is presented, and is as such a continuation of the analysis in Chapter 4 from 2009–2011. The analysis takes a slightly different angle to the analysis of the implementing measure for televisions in that it is based on a life cycle assessment analysis, whose phases and environmental impact categories are important when setting ecodesign requirements. The ecodesign requirements in the implementing measures have been set up following a specific methodology and the aim of the paper is to analyse whether the results of the methodology for setting ecodesign requirements for energy-using products are correct in stating that the most important impact is energy consumption in use phase. The research question that guides the analysis is:

*What life cycle phases and environmental impact categories are important when setting ecodesign requirements for televisions?*

In **Chapter 6 Conclusion Part I**, the three research questions are answered and the chapter constitutes the conclusion to Part I of the thesis.

# CHAPTER 3. THE ECODESIGN DIRECTIVE: AMBITIONS AND PRACTICE

The Ecodesign Directive is the focal point of this chapter. The focus is on the ambitions of the Directive in relation to the interplay with other policy instruments, how the concept of ecodesign is defined and how it is implemented in practice. Hence, the research question guiding the analyses is: *What is the role and ambition of the Ecodesign Directive and how is it implemented in practice?*

The question is answered in three parts. First, through an analysis of the dynamics in the Ecodesign Directive and its interplay with other policy instruments; second, through an analysis of the energy savings potential and achievements; and third, through an analysis of how the definition of ecodesign in the Directive and the interpretation of ecodesign in the implementing measures compares to the theoretical definition of ecodesign. However, before answering the research question, an introduction of the concept of ecodesign and an overview of the development within public environmental regulation is needed in order to understand the concept of ecodesign in theory and to understand the historical context in which the Ecodesign Directive emerged.

## 3.1. ECODESIGN: INTRODUCING THE CONCEPT

Before discussing how ecodesign is applied in regulation, an introduction of the concept is necessary. Victor Papanek was one of the first to emphasise the designers' opportunities to influence the environmental impact of products, through his book *Design for the Real World* from 1972 (Papanek & Fuller, 1972). Other concepts closely related to ecodesign are design for the environment and green design (Guidice, La Rosa & Risitano, 2006; Zbicinski et al, 2006; Mackenzie, 1997). Since the concept was first introduced, several definitions have appeared, but common for all is that they in some way are about integrating environmental concerns in the design stage of product development. In this thesis, the point of departure is in the definition by Tischner et al (2000, p.12, original highlights):

> 'Ecodesign means environmentally conscious product development and design. This term describes a systematic manner which aims at including environmental aspects in the product planning, development and design process at the earliest possible opportunity. This means that 'environment' is added as a criterion of product development alongside other classical criteria of functionality, profitability, safety, reliability,

> ergonomics, technical feasibility, and, last but not least, aesthetics. The term Ecodesign directly expresses the fact that **Eco**logy and **Eco**nomy must be joined inseparably by means of good **design** in Ecodesign procedures.'

The definition above specifically highlights that ecodesign concerns integrating environmental aspects alongside the economic aspects. As such, ecodesign takes into account two of three aspects of sustainable development, as defined by the Brundtland Commission in 1987 (World Commission on Environment and Development, 1987). The concept can be broadened to sustainable design, by including social and ethical issues (Tischner et al, 2000). Another important point is that the environmental aspects should be included in the product planning, development and design process at the earliest possible opportunity. This is important since later in the product development process, the degree of freedom for making changes in the product is lower. In this way, the largest potential for environmental improvements of a product is in the early stages of the process. Goosey (2004) estimates that up to 80% of a product environmental impact is determined in the design phase, which further underlines the importance of including environmental aspects at an early stage. The improvement potential of ecodesign is also dependent on the ambition level of the company and how radical the improvements are that they are willing to do. Ecodesign can include environmental improvement of both products, systems, infrastructure and services (Tischner et al, 2000). Ecodesign can range from gradual improvements of a product, over redesigned products, to the more radical function and system innovation. This graduation of ecodesign is analysed in more detail in Chapter 9 of this thesis.

Tischner et al (2000, p.13) continues the definition of ecodesign by highlighting that 'Life cycle thinking, i.e. a unified view of the entire product life cycle, is fundamental to Ecodesign. It covers the extraction of raw materials, the production process, and the distribution, use, recycling and, finally, disposal of products.' This implies that even though a company's traditional sphere of influence over a product ends at the company gate, the design of a product is able to influence the entire life cycle of the product, and should therefore be part of the considerations in the design and development of a product (Tischner et al, 2000).

In the literature, the focus has traditionally been on developing tools and procedures that can help the companies integrate ecodesign in their design and product development process (Brezet, van Hemel & Clarke, 1997; Boks, 2006; Bovea & Perez-Belis, 2012). The tools in ecodesign range from the retrospective and time-consuming tools aimed at assessing and documenting the environmental impacts of products, such as life cycle assessment, to tools for setting priorities and generating creativity and ideas, such as rules of thumb and checklists. Tools such as life cycle cost also enable the companies to coordinate different criteria (Tischner et al, 2000) Ecodesign can be improvements of single products, but guides for integrating ecodesign in the management systems have also been developed in order to secure continuous improvement (ISO 14006, 2011). With the realisation that tools alone are not enough for successful integration of ecodesign in the product development process, focus in the ecodesign literature has widened to include the ‘softer’ aspects, such as competence building and organisational structures and systems, which support learning and change processes (Boks, 2006; Charter, 2001). In Chapter 10 of this thesis, this subject is further analysed through a community of practice perspective.

## 3.2. ENVIRONMENTAL REGULATION AND THE EMERGENCE OF ECODESIGN IN REGULATION

Public environmental regulation emerged in the 1970s. In a Danish context, this is illustrated by the fact that the Ministry of Pollution Control was established in 1971. In 1973, the ministry changed its name to Ministry of the Environment in 1973. (Miljøministeriet, n.d.) On an EU level, the Environment Directorate-General of the European Commission was established in 1973 (European Commission, 2010).

The first regulations were what is traditionally called ‘command and control’ or ‘hard’ regulations, where undesired effects are removed by posing constraints on existing activities in society. Focus was placed on local and regional problems such as emissions to air, water and soil, and on the activities of the companies. Hence, consumption patterns and the product life cycle were not considered. On the contrary, the regulation focused on end-of-pipe technologies and dilution and not on pollution prevention  (Smink, 2002).

Around the 1980s the limitations of the command and control regulation were being discussed and new instruments began to supplement the traditional command and control regulations. Smink (2002) emphasises two types of instruments, i.e. economic instruments and communicative instruments. Economic instruments are defined by Hockenstein, Stavins and Whitehead (1997) as ‘regulatory devices that shape behaviour through price signals rather than on explicit instructions on pollution control levels or methods’. The idea behind economic instruments is that if the total cost of an environmentally friendly good or service is lower than the alternative, the rational choice is the cheapest alternative, and hence, the most environmentally friendly alternative (Winsemius, 1986 cited in Smink, 2002). Empirical evidence, however, suggests that economic instruments can lead to behavioural changes in the short-term, but for long lasting changes to occur, the motivation must not come from an outside force but from the individual (Pape et al, 2011). Examples of economic instruments are pollution charges, taxes, subsidies, tax rebates, deposit-refund systems and emission trading (UNEP, 2005; Bailey & Ditty, 2009; Sridhar, 2011).

With communicative instruments, governments use information and education to try to influence the behaviour of consumers and companies (Smink, 2002). The communicative instruments are not prescribed by legislation, as they do not directly interfere with the company behaviour. They are, therefore, also often referred to as 'soft instruments' (Cleff & Rennings, 1999). Communicative instruments can be unilateral, where governments pass on information to the consumer or company through, for instance, television, newspapers, brochures or ecolabels, and in this way influence the behaviour of the consumer or company. Communicative instruments can also be based on an interaction between the actors involved, i.e. governments, consumers and companies. Voluntary agreements, which are written agreements between government and industry on the implementation of an environmental policy, are examples of such communicative instruments (van der Peppel & Herweijer, 1994 cited in Smink, 2002). A shortcoming of the use of communicative instruments is the anticipation that by merely providing access to accurate information, it leads to behavioural change. On the contrary, empirical evidence suggests that information together with other incentives is necessary in order to create change (Pape et al, 2011).

### 3.2.1. SUSTAINABILITY BECOMES PART OF THE POLITICAL AGENDA

The introduction of new instruments in environmental regulation was a part of a transition in the widening of the scope of the environmental regulation. In 1987, the Brundtland Commission's report, *Our Common Future*, was published, putting the concept of sustainable development on the international agenda (World Commission, 1987). In the EU, the Treaty of Amsterdam in 1997 included the concept of sustainable development as an overarching objective of EU policies (European Commission, 2012). The first Strategy for Sustainable Development was issued in 2001, and was since revised in 2006 and 2009. The strategies present a framework for a long-term vision of sustainability, where environmental protection, social cohesion and economic growth must go hand-in-hand and are mutually supporting. The focus in latest strategy from 2009 is climate change and the transition to a low carbon economy (European Commission, 2009b). Other subjects concern clean energy, sustainable transport, sustainable consumption and production, conservation and management of natural resources, public health, social inclusion, demography and migration, global poverty and sustainable development challenges (European Commission, 2012).

The concept of integrated product policy was developed during the 1990s, reflecting the described transformation in environmental policy from government to governance (Scheer, 2006). In 2003, the integrated product approach was introduced by the Commission as part of the Strategy for Sustainable Development, and as a reaction to the fact that the quantity, variety and complexity of products is increasing, new types of products are constantly introduced to the market, and products are, now more than ever, traded globally. This means that more actors are involved throughout the products' lifetime and have an influence on the environmental impact of the product (European Commission, 2003). The integrated product approach aims at reducing the environmental impact of products in their entire life cycle from raw material extraction to production, distribution use and waste management (European Commission, 2001). The approach is based on five key principles: life cycle thinking, working with the market, stakeholder involvement, continuous improvement and a variety of policy instruments (European Commission, 2003).

In 2008, the Commission presented, and the Council endorsed, the Sustainable Consumption and Production Action Plan. The Action Plan contains 'the strategy of the Commission to support an integrated approach in the EU, and internationally, to further sustainable consumption and production and promote its sustainable industrial policy' (European Commission, 2008b p.2). The Action Plan as such consists of a framework complementing existing policies, and the aim is to improve the energy and environmental performance of products and promote their uptake by consumers (European Commission, 2008b). Policies explicitly mentioned in the Action Plan are the Ecodesign Directive, Labelling of Products and Green Public Procurement. These are all regulations, which also are part of the EU's integrated product policy, presented above.

### 3.2.2. THE FOCUS CHANGES TO RESOURCE EFFICIENCY

Around 2010, the political agenda in the EU began a change from being focused on sustainable development to the new key word—resource efficiency. The main initiator for putting resource efficiency on the political agenda is the Europe 2020 strategy launched in 2010. The strategy establishes five overall targets: employment, research and development, climate/energy, education, social inclusion and poverty reduction. These targets must be reached by 2020. Following the strategy, seven flagship initiatives were launched. These provide a framework for the initiatives within the areas of highest priority. One of these flagships is the *flagship initiative for a resource efficient Europe*, which supports the shift towards a resource-efficient, low carbon economy, and to achieve sustainable growth. (European Commission, 2014) The flagship is further specified in the *Roadmap to a Resource Efficient Europe*, which sets visions, milestones and actions and it identifies four areas that require action when moving towards a resource-efficient Europe. These areas are sustainable consumption and production (1), turning waste into a resource (2), supporting research and innovation (3) and environmental harmful subsidies and getting the prices right (4). The roadmap furthermore identifies seven resources, e.g. biodiversity, water and air, and milestones and actions are defined on how to improve the efficiency of these resources. In addition, food, buildings and mobility are identified as key sectors that should be a focus for the European initiatives on resource efficiency (European Commission, 2011).

Under the sustainable consumption and production focus area of the *Roadmap*, the Ecodesign Directive is mentioned as an instrument to boost material resource efficiency of products, and it is emphasised that a widening of the scope to non-ErPs should be considered and include more resource relevant criteria (European Commission, 2011). In the communication from the Commission, *Towards as circular economy: A zero waste programme for Europe* from 2014, the Ecodesign Directive was also highlighted as an action point for the Commission to support design and innovation for a more circular economy. The Commission will ‘further develop the application of the Ecodesign Directive by paying further attention to resource efficiency criteria, including for the future priority product groups in the 2015- 2017 Work Plan’ (European Commission, 2014b, p.6).

Also, the 7th Environmental Action Plan from 2013 puts resource efficiency on the agenda. The action plan presents a 2050 vision, which is intended to guide the actions until 2020 and beyond. Furthermore, the action plan defines priority objectives for the Union to fulfil this vision. The second priority objective is: ‘To turn the Union into a resource-efficient, green and competitive low carbon economy’ (European Commission, 2014c, p.32). The priority objective refers to—among other things—the resource-efficient Europe flagship initiative and its roadmaps as important instruments to achieve a resource efficient Europe. Furthermore, it is emphasised that the Ecodesign Directive along with the Energy Labelling Directive and the Ecolabel Regulation will be reviewed, aiming at improving the resource efficiency and environmental performance of products in their lifecycle (European Commission, 2014c)

In Figure 8, an overview is given of the above presented historical context of which the Ecodesign Directive has emerged. The arrows illustrate where the Ecodesign Directive is a part.

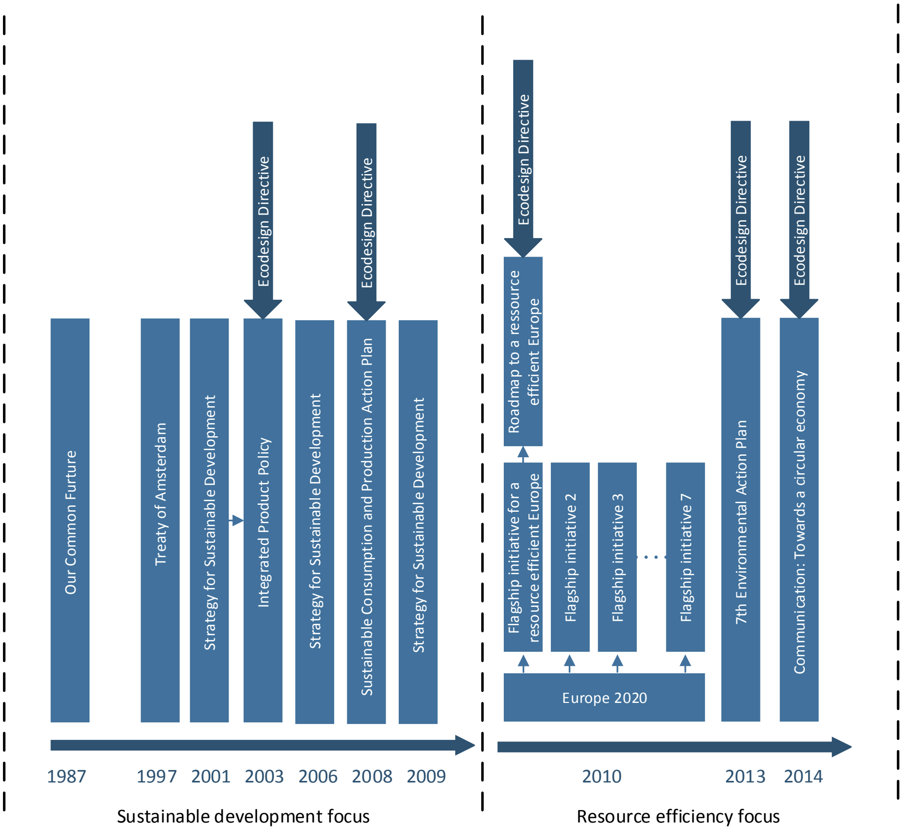


*Figure 8: The public environmental regulation context in which the Ecodesign Directive has emerged.*

In the following section, the Ecodesign Directive is introduced.

## 3.3. INTRODUCTION OF THE ECODESIGN DIRECTIVE

The Ecodesign Directive was adopted in 2005 and establishes a framework for setting ecodesign requirements for energy-using products. In 2009, the Directive was recast to cover energy-related products as well. The objective of the Directive is to ensure free movement on the market of products in compliance with the ecodesign requirements and 'it contributes to sustainable development by increasing energy efficiency and the level of protection of the environment, while at the same time increasing the security of the energy supply' (European Commission, 2009, Article

1.2) The Ecodesign Directive is part of the CE marking, which implies that non-compliant products cannot be marketed in the EU.

The Directive is a framework directive, which implies that requirements to products are given in so-called implementing measures or through voluntary agreements. The implementing measures are regulations, which have direct legal effect in the member states.

The Ecodesign Directive allows for two types of requirements in the implementing measures; generic and specific ecodesign requirements. Both types of ecodesign requirements aim at improving the environmental performance of products. Generic ecodesign requirements focus on significant environmental aspects and do not set limit values. Specific ecodesign requirements focus on a selected environmental impact and do set limit values (European Commission, 2009, Annex I and II). The requirements are often set up in two tiers, where a first set of requirements come into force at a specific time, and a second set of requirements, which are stricter than the first set, come into force some years later. In this way, a continuous improvement mechanism is integrated, and it allows industry to prepare for the stricter requirements.

## 3.4. THE DYNAMICS OF THE ECODESIGN DIRECTIVE AS POLICY INSTRUMENT

Along with the Ecodesign Directive, the EU Commission has adopted several policy instruments, which are aimed at contributing to sustainable development; these are, for example, the RoHS Directive, the WEEE Directive, the REACH Regulation, the Energy Label, the European Ecolabel and Green Public procurement criteria. Details on these policy instruments are found in Appendix B and D. The dynamics of these different instruments are threefold (see Figure 9). The Ecodesign and RoHS Directives and the REACH Regulation set minimum requirements for products' environmental performance, thereby removing products from the market that do not comply with the legislation. The European Ecolabel and green public procurement (GPP), on the other hand, aim at encouraging environmental improvements. The European Ecolabel sets voluntary requirements, with the aim that only the best performing products on the market will be able to comply. The idea is that the ecolabels are continuously updated and tightened to ensure that only the best performing products can comply with the requirements. In this way, the ecolabels create incentives that pull the market towards more environmentally friendly products. GPP is a voluntary instrument through which public authorities seek to procure goods, services and works with a reduced environmental impact (European Commission, 2008c). The Energy Label covers the entire span of products on the market with the aim of informing the consumer of the performance level of the given product. In this way, the Energy Label also creates a pull from the market towards more environmentally friendly products.

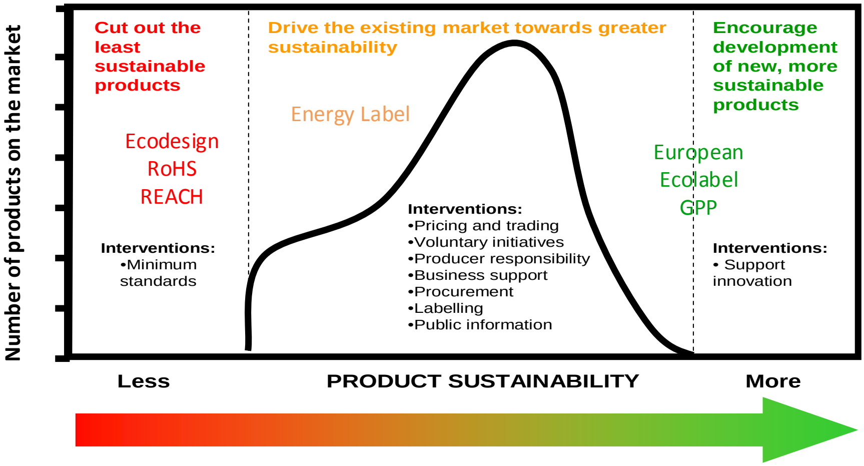


*Figure 9: The scope of the different policy instruments aimed at sustainable development. Based on (Galatola, 2015).*

A strength of the instruments setting minimum requirements is that it will expel the worst performing products from the market if the ambition level of the requirements is suitable. Furthermore, in the case of the Ecodesign Directive and the regulations implementing it, the opportunity for continuous improvement is provided. This is due to the dynamic approach with the gradually stricter requirements, and the regulations that are revised at certain intervals. An evaluation of the Ecodesign Directive from 2012 concludes that the Ecodesign Directive as a policy instrument is well placed within the context of the Europe 2020 Strategy, its flagship initiatives and the SCP/SIP Action plan (CSES and Oxford Research, 2012). The evaluation also concludes that the main purpose of removing the worst performing products from the market is appropriate (CSES and Oxford Research, 2012). An evaluation of the Energy Labelling Directive and certain aspects of the Ecodesign Directive from 2013/2014 agree by concluding that the Energy Labelling and Ecodesign Directives are capable of generating substantial savings cost-effectively (Molenbroek et al, 2014).

Looking at the achievements of the specific implementing measures of the Ecodesign Directive, the 2012 evaluation concludes[2] that the implementing measures for domestic and tertiary lighting have a positive impact on energy efficiency, which is mainly related to the ban of incandescent lamps. The implementing measures for standby and off mode, and to a lesser degree for circulators in buildings, have also had an indirect role in the energy efficiency improvements. Furthermore, the implementing measures for electric motors are expected to make a substantial contribution to changes. For the product groups, televisions, domestic cold appliances, domestic washing machines and dishwashers—the energy efficiency improvement of the products on the market cannot be directly linked to the implementing measures, but the implementing measures may have amplified the trend, causing the development to happen faster. (CSES and Oxford Research, 2012).

Returning to the research question concerning the ambition of the Ecodesign Directive, it can be concluded that the Ecodesign Directive, given its imbedded dynamic of setting minimum requirements, ensures that the products available on the market meet a minimum environmental standard. The level of this minimum environmental standard is determined by the requirements in the implementing measures, and the potential for encouraging industry to environmentally improve its products is present. This is illustrated in the evaluation of the Directive, which shows that the Directive does provide potential for environmental improvements of products. For certain product groups, energy efficiency improvements directly related to the Ecodesign Directive and its implementing measures are detected, whereas for other product groups, the improvements cannot be linked directly to the Ecodesign Directive and its implementing measures. Other instruments such as the Energy Label have, however, contributed to the change in consumer behaviour.

### 3.4.1. THE ENERGY SAVINGS POTENTIAL OF THE ECODESIGN DIRECTIVE

Even though there are measurable, positive impacts of the Ecodesign Directive and its implementing measures, both evaluations of the Ecodesign Directive argue that the full energy savings potential of the Ecodesign has not been reached due to low ambitions levels, among other things (Molenbroek et al, 2014; CSES and Oxford Research, 2012). A report from the 'coolproduct for a cool planet' campaign supports these findings. Based on an analysis of the implementing measures or draft regulations for televisions, domestic refrigerators, domestic lighting, domestic

[2] Two limitations of the 2012 evaluation should be taken into consideration when reading the conclusions. First, at the time of the evaluation most of the implementing measures had recently been introduced, which implied that in most cases the tier 2 requirements had not yet come into force, and secondly, for most products, recent data was missing (CSES and Oxford Research, 2012).

washing machines, water heaters and boilers, the report from the coolproduct for a cool planet campaign concludes that the minimum requirements in the implementing measures do not include all the cost-effective savings that are possible. The report argues that the energy savings are not only feasible, but also cost-effective, and that even though the energy effective product may seem expensive at the time of purchase, from a lifetime perspective, these products are less expensive than the base cases (Ballu & Toulouse, 2010). The evaluation of the Directive from 2013/2014 highlights an interesting dispute in the stakeholder survey concerning the ambition level of the implementing measures. The stakeholder survey finds that most stakeholders, except industry, agree that for some implementing measures and labels, the ambition level is right, whereas for others it is too low compared to what is technically and economically feasible. The industry, in contrast, finds the ambition level to be right or too high. Specifically for television, it is the only example where all stakeholders, except industry, assess the ambition level to be too low or much too low. The industry assesses the ambition level to be correct (Molenbroek et al, 2014).

One reason for the low ambition levels in the implementing measures is the lengthy procedures for developing the implementing measures as they lead to outdated technical and preparatory work (CSES and Oxford Research 2012, Molenbroek et al, 2014). The coolproduct for a cool planet campaign argues that the current process, where it on average takes four years to develop requirements and then another three to four years before the requirements are in force, is too slow. It is not dynamic and challenging enough to change the business as usual approach in the companies, and it is furthermore failing to reward the businesses that have invested in innovative and efficient technologies (coolproducts, 2011b; coolproducts, 2010) The delays have in the case of boilers and water heaters led to missed opportunities, and also in these cases the negotiations between the member states and stakeholders are a reason for the delays. Additionally, the 2012 evaluation of the Ecodesign Directive emphasises that in general, if the requirements in the implementing measures are outdated by the time of adoption, they do not reflect the market trends and technological developments, and therefore, opportunities for environmental improvements are lost (CSES and Oxford Research, 2012). The television case is particularly highlighted by NGOs as a worst-case example, and the concern is that not only do the long processes lead to out-dated and unambitious requirements, they also result in many lost years, where the energy savings are not realised (Juul, 2012; Arditi, 2013). The coolproducts for a cool planet campaign, furthermore, questions the effectiveness in that there are no strict deadlines for finalising the regulation, which means that there are no consequences if the process drags out (Arditi, 2013).

The main reason for these lengthy processes is, according to the 2012 evaluation of the Ecodesign Directive, the limited resources in the Commission. The inadequacy of the Commission resources is considered a major constraint in the entire ecodesign system (CSES and Oxford Research, 2012). This is also emphasised by the European Environmental Citizens Organisation for Standardisation (ECOS), which argues that the understaffing in the EU Commission is one of the causes for the delayed processes of adopting and developing the requirements in the implementing measures. ECOS calls for the involvement of other DGs besides DG Enterprise and DG Energy, who are responsible for the Ecodesign Directive, and also for more staff in the different DGs to handle the issues around the Ecodesign Directive (Toulouse & Tolbaru, 2012). In particular, 2010 is emphasised as a year where only three implementing measures were adopted due to long procedures and understaffing in the commission (coolproducts, 2011).

Weak enforcement and market surveillance are other reasons why the full savings potential of the Ecodesign Directive has not been reached (CSES and Oxford Research 2012; Molenbroek et al, 2014). According to the 2012 evaluation of the Ecodesign Directive, non-compliance is in the range of 10–20% due to the member states not having dedicated the necessary resources, and it is posing a threat to the credibility of the Directive and is undermining the efforts of the industry (CSES and Oxford Research, 2012).

On this basis, it can be concluded that the Ecodesign Directive and the implementing measures have had a positive effect on increasing energy efficiency, but that the full energy savings potential has not been utilised. Answering the research question concerning the ambition of the Ecodesign Directive, this implies that the ambition of the Directive is rather low. The interplay with other regulations is important in order to widen the scope from mere energy efficiency and to drive the technological development towards more energy efficient solutions. As the 2012 evaluation of the Ecodesign Directive concludes, the implementation of the Ecodesign Directive has a positive role in encouraging the adoption of existing innovative technologies and the promotion of innovation. However, for the time being, the identification of advanced benchmarks in the implementing measures seem to have a limited effect, and their role in promoting BAT and innovation could be strengthened (CSES and Oxford Research, 2012).

The Energy Labelling Directive is an example of a policy instrument that has been successful in increasing the market share of A and A+ labelled products since the adoption of the label in 1992 (Waide, 2001). Furthermore, as mentioned, the 2013/2014 evaluation of the Energy Labelling Directive and certain aspects of the Ecodesign Directive conclude that these instruments together are able to generate substantial savings cost-effectively (Molenbroek et al, 2014). Finally, the coordination with, for instance, the Ecolabel scheme could be improved in order to include other aspects besides energy efficiency in the scope of the Ecodesign Directive. The 2012 evaluation of the Ecodesign Directive concludes that the Ecodesign Directive in its implementation is effectively linked to the Energy Labelling Directive, but that the coordination with the GPP and European Ecolabel scheme has not been strong. Furthermore, the interface with related legislation, such as the WEEE and RoHS Directives, is a challenge with a number of grey areas, which may lead to inaction or missed opportunities (CSES and Oxford Research, 2012).

In the following section, the interplay between the Ecodesign Directive and the other policy instruments aimed at contributing to sustainable development is analysed, beginning with an analysis of how the concept of ecodesign is defined and interpreted by the Ecodesign Directive its implementing measures.

## 3.5. THE INTERPRETATION OF ECODESIGN IN THE ECODESIGN DIRECTIVE

In the Ecodesign Directive, ecodesign is defined as, 'The integration of environmental aspects into product design with the aim of improving the environmental performance of the product throughout its whole life cycle' (European Commission 2009, Article 2.23).

Environmental aspects are defined as, 'An element or function of a product that can interact with the environment during its lifecycle' (European Commission 2009, Article 2.11).

Based on these definitions it appears that the Ecodesign Directive takes a holistic viewpoint on ecodesign in that the definition includes the entire lifecycle of the product. Furthermore, the environmental aspects, which can be included, are not limited as they can concern both elements, e.g. materials and functions of the products as long as they interact with the environment. The definition of ecodesign in the Ecodesign Directive is in line with the theoretical definition of ecodesign presented in section 3.1; however, in order to understand how this definition is interpreted in practice, it is necessary to analyse the implementing measures that implement the Ecodesign Directive.

### 3.5.1. ENVIRONMENTAL AND LIFE CYCLE FOCUS AREAS OF THE IMPLEMENTING MEASURES

In Appendix C, an analysis of the 11 implementing measures adopted as of February 2011 is presented. The focus in the majority of the implementing measures is energy consumption and energy efficiency and the use phase. Only the two implementing measures for lighting and the one for washing machines set requirements for issues that do not just relate to energy consumption or energy efficiency. However, concerning information requirements all the implementing measures except four include information requirements regarding other aspects besides energy. The reason for this unilateral focus on energy is in some cases given in the preamble to the regulations. Here it is stated either that only the most important impacts are addressed, or as in the case for televisions, tertiary and domestic lighting reference are given to the WEEE and RoHS Directives concerning waste and hazardous substances (European Commission, 2009c, preamble 7; European Commission, 2009d, preamble 21; European Commission, 2009e, preamble 9).

The 2012 evaluation of the Ecodesign Directive argues that the focus on energy efficiency issues is mainly a result of the products in scope in the 2005 Directive being energy-using products and policy choices based on the technical analysis in the preparatory studies and available data. Policy choices and the technical analysis are also the reasons for some non-energy-related issues not being regulated in the adopted implementing measures (CSES and Oxford Research, 2012).

The unilateral focus on energy and the use phase is criticised by many. Two reports are emphasised in the following, one from the European Environmental Bureau (EEB) and another from the Nordic Council of Ministers. Based on an analysis of the implementing measures for computers, televisions, domestic refrigerators and lighting, the EEB report concludes that the importance of energy in the use phase may be overestimated, particularly regarding monitors and televisions. It is argued in the report that the source of this unilateral focus is the product lifespan and boundaries applied in the MEErP methodology. The report refers to other studies that in contrast to the preparatory studies, show that the production phase has the highest environmental impacts (van Rossem & Dalhammar, 2010). The 2012 evaluation of the Ecodesign Directive, however, concludes that although aspects of the MEEuP and the EcoReport tool have been criticised, the main purpose of the MEEuP is fulfilled regarding identifying significant environmental aspects and relevant requirements. Furthermore, the evaluation concludes that thorough and good quality research in both the working plan and the preparatory studies can subsequently save both time and money (CSES and Oxford Research, 2012).

Furthermore, the EEB report argues that the implementation of the Directive in implementing measures, in general, has shown a steady downgrading from applying a total life cycle methodology to merely considering energy in the use phase and that other aspects are only treated vaguely (van Rossem & Dalhammar, 2010). The report from the Nordic Council of Ministers includes a case study of the implementing measures for washing machines, including an analysis of the performance of the washing machines on the market in 2011. The analysis confirms the results of the EEB in that for the implementing measures for washing machines, the focus predominantly concerns energy consumption in the use phase, neglecting other life cycle phases (Bundgaard, Zacho & Remmen, 2013).

Furthermore, the focus on impacts and hot spots also means that the other part of the directive regarding ‘significant improvement potentials’ is not really taken into account. In other words, several options for improvement are not considered due to a blind spot on this part of the scope of the directive.

On this basis, it can be concluded that despite the comprehensive definition of ecodesign in the Ecodesign Directive, it is in the implementation of the Ecodesign Directive through the implementing measures that the scope is narrowed to mainly energy and use phase. The focus in the Ecodesign Directive is on improvement of the products, which implies that a more radical ecodesign with a focus on functions and system innovation will not likely be an outcome of the Ecodesign Directive. As the regulations appear to refer to other directives for environmental aspects other than energy, the following section analyses which environmental aspects and life cycle phases the different policy instruments include.

### 3.5.2. ENVIRONMENTAL AND LIFE CYCLE FOCUS AREAS OF THE POLICY INSTRUMENTS

A brief analysis of the RoHS, WEEE and Energy Labelling Directives, the REACH Regulation, the European Ecolabel and Green Public Procurement Criteria are presented in Appendix B and D. Based on these analyses it appears that each policy instrument focuses on a particular life cycle stage and environmental aspects (see Figure 10). Only the voluntary instrument the European Ecolabel sets requirements to the entire life cycle of the product, whereas all mandatory instruments focus on one life cycle phase of the product.

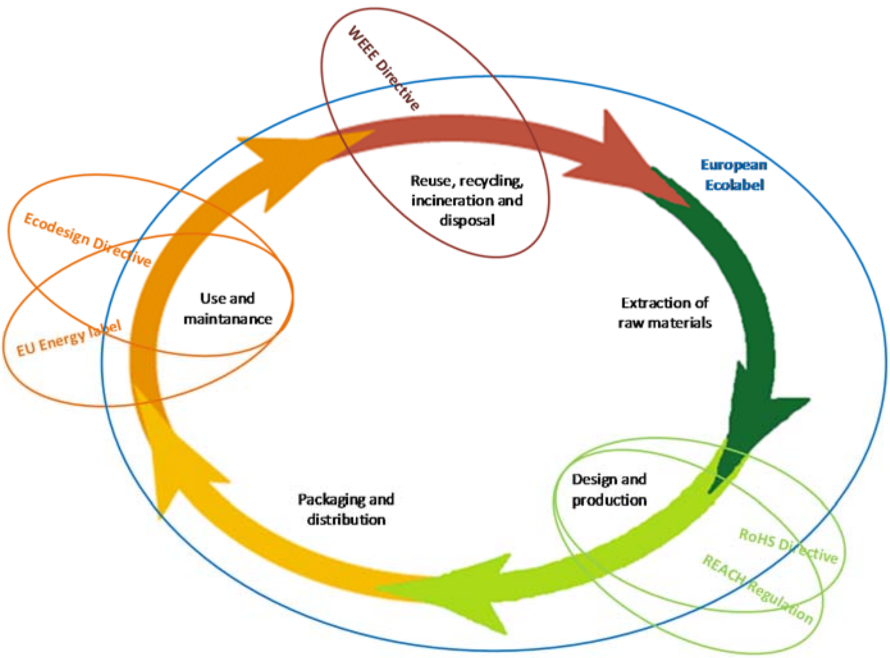


*Figure 10: The phases of a product's life cycle covered by the different policy instruments (Huulgaard & Remmen, 2012).*

What is evident from Figure 10 is that instruments are available, which aim at environmental improvements of products in their entire life cycle. However, in order to address the packaging and distribution phase and the extraction of raw materials stage, it is necessary to include the voluntary instruments such as the European Ecolabel. There are deficiencies though, as also highlighted in Appendix B and D. For instance, regarding the RoHS Directive, an impact assessment initiated by the European Commission in relation to the recast of the RoHS Directive, reveals non-compliant rates as high as 44% of the member states (European Commission, 2008). A study published by the EEB highlights that the WEEE Directive especially does not appear to really fulfil its objective of providing incentives for the producer to integrate considerations about the product's end of life phase and recycling options in the design phase, because of national deficiencies in the implementation of the individual producer responsibility (van Rossem & Dalhammar, 2010). The study introduces 'the passing the buck' strategy, which appears to be adopted between the different policy instruments. The concern expressed in the study relates to the many overlapping objectives of the WEEE, RoHS and Ecodesign Directive and the implementation of the directives. The report emphasises the fact that even though the directives have positive impacts, there are still significant improvement potentials and gaps. Examples are the slow development of compliance systems for the WEEE Directive in many member states, the lack of adding to substances in the RoHS Directive, and that the implementing measures under the Ecodesign Directive tend to refer to the RoHS Directive regarding chemicals. Furthermore, the report problematises the proposals for revising the WEEE and RoHS Directive, where the focus appears to be towards avoiding internal market difficulties rather than on creating an effective and synergetic link to the Ecodesign Directive (van Rossem & Dalhammar, 2010).

On this note, the conclusion is that there appears to be deficiencies in the interplay between the implementation of the different policy instruments. Hence, significant improvement potentials still exist for the implementation of the Ecodesign Directive in terms of widening the focus from energy and the use phase. However, in line with the general shift in focus in the EU, as presented in section 3.1, there have been some changes towards including resource efficiency in the implementing measures. This is discussed in the following section.

### 3.5.3. INCLUDING RESOURCE EFFICIENCY IN THE IMPLEMENTING MEASURES

The first steps in moving from focusing mainly on energy and energy efficiency are taken with the recast of the Ecodesign Directive in 2009, where the scope of the Directive is expanded from energy-using products to energy-related products. Through this expansion, the opportunity of including other environmental impacts and improvement potentials besides energy consumption is increased. This development is further supported by the evaluation of the Ecodesign Directive in

2012. The evaluation concludes that for some product groups still under consideration, possible improvement potentials not related to energy in use phase have been identified, such as improvements of material efficiency. Some of these qualify for requirements under the Ecodesign Directive, whereas others would be better achieved through other EU legislation (CSES and Oxford Research, 2012).

Since the analysis of the Ecodesign Directive and its implementing measures in this PhD study was finalised the first time in 2011, several new implementing measures and voluntary agreements have been adopted. Looking at the requirements that are set up in them, a slight transition towards including other aspects besides energy consumption in the use phase is visible. As shown in Appendix C, already by 2011, the implementing measure for washing machines included requirements on water consumption and the implementing measure for tertiary and domestic lighting included performance requirements. Furthermore, information requirements were included in most implementing measures covering resource efficiency aspects. In Bundgaard, Remmen and Zacho (2015), an overview of the resource efficiency requirements in 21 implementing measures and two voluntary agreements, which were adopted at the time, is presented. It reveals that six implementing measures and one voluntary agreement contain both specific ecodesign requirements and information requirements. In nine of the new implementing measures only information requirements are set up. This implies that six of the adopted implementing measures and one voluntary agreement do not include any resource efficiency requirements at all. This indicates that resource efficiency is on the agenda in the Ecodesign Directive, but mostly concerning information requirements.

Based on a case study of the implementing measures for vacuum cleaners and the voluntary agreement for imaging equipment, the report concludes that resource efficiency requirements are included for these categories late in the policy process due to pressure from different stakeholders, but also that resource efficiency in both cases is regarded as having significant environmental impacts (Bundgaard, Remmen & Zacho, 2015). Furthermore, the report concludes that several barriers need to be overcome in order for resource efficiency to be included in the implementing measures and voluntary agreements. For example, an organisational barrier is that the Ecodesign Directive is primarily embedded in DG Energy and DG Enterprise. DG Environment, in particular, has expertise and interest in resource efficiency, and will be able to strengthen the linkage to the ecolabels and initiatives related to the circular economy.

Furthermore, several other barriers are highlighted by Bundgaard, Remmen and Zacho (2015). The measurement and test standards are not fully mature to include resource efficiency aspects. Consumers do not experience the same benefits when purchasing a resource efficient product compared to an energy efficient product, unless it also includes durability or reparability. Finally, parts of the industry may oppose requirements such as durability, because such requirements may influence their business negatively, especially if they are on a price competitive market.

The drivers for including resource efficiency aspects are according to the report that resource efficiency aspects are part of the ecodesign parameters that need to be considered for products if they are found significant. This implies that the framework conditions are available. Furthermore, resource efficiency is on the political agenda, which makes the policy makers more receptive towards including such aspects, and finally, pressure from various stakeholders has been a driving force for including resource efficiency aspects in the implementing measures or voluntary agreements (Bundgaard, Remmen & Zacho, 2015).

Further examples supporting that resource efficiency is now a part of the political agenda in the EU and is being built into the implementing measures of the Ecodesign Directive, are three different projects initiated by the European Commission. The first project, Material-Efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP), was published in 2013, with the aim of assessing the possibilities of enhancing material efficiency aspects in MEErP. The project consists of two parts; one part clarifies the implications of material efficiency from a practical application perspective and recommendations for the MEErP, and the second part is an update of the MEErP and the EcoReport tool to include material efficiency issues (European Commission, 2014d).

The second project initiated by the European Commission is called, 'Integration of Resource Efficiency and Waste Management Criteria in the Implementing Measures under the Ecodesign Directive', from 2012. The overall purpose of the project is to analyse the feasibility and opportunity of developing resource efficiency requirements in the Ecodesign Directive. The project consisted of two phases, each including three reports. The areas covered by the reports are a review of resource efficiency and end-of-life requirements; in-depth analysis of the measurement and verification approaches, identification of possible gaps and recommendations; contribution to impact assessment; analysis of durability; application of the project's methods to three product groups; and redefined methods and guidance documents for the calculation of indices concerning reusability/recyclability/recoverability/recycled content, use of priority resources, use of hazardous substances, durability (Ardente et al, 2011; Ardente et al, 2011b; Ardente et al, 2011c; Ardente, Mathiuex & Forner, 2012; Ardente & Mathiuex, 2012; Ardente & Mathiuex, 2012b).

The third project was recently launched and it concerns the development of a methodology to assess the durability of products. The methodology could potentially be used both in the Ecodesign Directive and the Ecolabel Regulation (European Commission, 2014e). Furthermore, CEN and CENELEC have received a mandate to develop a harmonised standard on material efficiency aspects in ecodesign. The work will, among other aspects, focus on extension of product lifetime, the ability to reuse components or recycle materials from products at end-of-life, the ability to recover energy from products at end-of-life and use of re-used components and/or recycled materials in products (European Commission, 2015).

Although the progress is recognised and welcomed, improvements are still necessary. The evaluation of the Ecodesign Directive in 2013/2014 concludes that other environmental impacts, besides energy in the use phase, could receive more attention (Molenbroek et al, 2014). The critique is in some cases also directed at specific implementing measures, for instance, in the case of water heaters. The concern is that an operating mode is not specified in the regulation, leaving it up to the producer to determine the mode for testing the energy efficiency. This creates an opportunity for the producer to test the products in any mode, even a fictional mode, which provides the best test results, and the consumers have no chance of knowing that the product they are purchasing in practice has a much higher energy consumption than the test results show (Spiliotopoulos, 2014). Furthermore, the cool products for a cool planet campaign highlights, for instance, embedded energy as an important and overlooked aspect. They express concern that even though recycled content by the project called, 'Integration of Resource Efficiency and Waste Management Criteria in the Implementing Measures under the Ecodesign Directive', was identified as a promising area to consider, it is not included in a draft mandate (Arditi, 2014). Secondly, based on the trend of purchasing bigger and more sophisticated appliances, the concern is raised that there is a need for setting absolute requirements instead of focusing on energy efficiency (Hunter, 2014). An example is the implementing measure for vacuum cleaners, which has set a cap on the energy consumption across all household vacuum cleaners, at a maximum 1,600 Watts from September 2014 (Spengler, Jepsen & Ausberg, 2014).

From the above, it can be concluded that several initiatives exist, which aim at widening the scope of the Ecodesign Directive and its implementing measures beyond energy and the use phase. In addition, it should be noted that due to the continuous improvement of the energy efficiency of the products, other aspects will become more important over time. However, even though these steps have been taken, the critique is persistent that the improvement potential is still higher.

## 3.6. CONCLUSION

The aim of this chapter was to answer the research question: *What is the role and ambition of the Ecodesign Directive and how is it implemented in practice?*

The role of the Ecodesign Directive is as a framework directive for setting ecodesign requirements for energy-using and energy-related products. The aim is to remove the worst performing products from the market by setting minimum requirements and thereby contribute to sustainable development.

The analysis of the Ecodesign Directive revealed that the definition of ecodesign in the Directive is in line with the theoretical understanding of the term, and the Ecodesign Directive does provide the basis for setting comprehensive ecodesign requirements with significant potential for environmental improvements of products. However, the analysis of the focus areas of the adopted implementing measures revealed that in practice, ecodesign requirements are merely set up for one environmental parameter and one life cycle phase, namely, energy and the use phase. The reasons for this narrow scope are the initial scope of the Directive, namely energy-using products, the methodology applied for establishing the ecodesign requirements, the missing focus on improvement potentials, and that only the most significant environmental impacts are included in the requirements. Furthermore, despite the fact that there are energy efficiency improvements directly linked to the Ecodesign Directive and its implementing measures, the ambition level in the requirements are continuously being criticised for being too low. One explanation is the lengthy adoption procedures, which result in outdated requirements, as in the case of televisions. On this basis, it can be concluded that the Ecodesign Directive and the implementing measures have had a positive effect on energy efficiency, but that the full potential has not been utilised.

The Ecodesign Directive alone can only drive the technological development and promote BAT and innovation to some degree. The interplay with other policy instruments is imperative, but deficiencies are still prevalent, and therefore, significant improvement potential exists for widening the focus from energy and the use phase. The link between the Ecodesign Directive and the Energy Label is clear due to their focus on energy and their different means; Ecodesign Directive setting minimum requirements and the Energy Label creating a pull from the market towards more environmentally friendly products. Currently, the European Ecolabel is essential for including considerations to other aspects besides energy, and by including resource efficiency and streamlining the definitions, requirement levels and the review rate of the requirements could strengthen the interplay. Finally, concern is raised about the many overlapping objectives of the WEEE, RoHS and Ecodesign Directive, which leads to a ‘passing the buck’ strategy, where the different directives refer to each other, with the result that certain environmental aspects in are not dealt with by any of the directives.

Several initiatives exist, aiming to widen the scope of the Ecodesign Directive and its implementing measures beyond energy and the use phase. The analysis of the implementing measures adopted since 2011 also reveal that the progress in terms of setting requirements to other environmental impact categories and life cycle phases than energy in the use phase appears to be slow but steady. On the positive side, the opportunity for continuous improvements is provided due to the dynamic approach with the gradually stricter requirements, and the regulations that are revised at certain intervals. However, so far, the main requirements not related to energy are information requirements. The change in the political agenda in the EU, however, might influence this, since the Ecodesign Directive is mentioned in several political strategy documents as a strong policy tool to integrate resource efficiency, and the inclusion of such requirements is encouraged.

Despite the progress, there is a persistent critique that the improvement potential has not been reached. This is an indication of the constant negotiation process or perhaps even policy battle. This is illustrated by the stakeholder survey in the 2013/2014 evaluation, where the industry almost consistently argued that the requirement level was either suitable or too high, whereas other stakeholders including NGOs found the requirements suitable or too low. However, the constant questioning of the current processes and requirement levels are necessary to continuously drive progress towards continuous improvements of environmental performance including a broader scope. This is illustrated by the example given in section 3.5.3, where the resource efficiency requirements in the implementing measures for vacuum cleaners and the voluntary agreement for imaging equipment were included, partly because of pressure from various stakeholders and because of existing standards that make it feasible.

The following chapter presents an in depth study of the implementing measure for televisions, focusing on the ambition and achievements concerning this product group.

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# CHAPTER 4. A CASE STUDY OF THE IMPLEMENTING MEASURE FOR TELEVISIONS

The point of departure for this chapter is an analysis of the implementing measure for televisions conducted in 2009–2011, and which is published in the report, 'Eco-design Requirements for Televisions: How Ambitious is the Implementation of the Energy-Using Product Directive?' by the Danish Ministry of the Environment in 2012. The aim of the chapter is to answer the following research question: *What are the achievements and ambition of the Ecodesign Directive, based on the implementing measure for televisions?*

The chapter begins with a summary of the analysis of the case study from 2009 to 2011. The full case study can be found in Appendix B and C. Following the summary, the main conclusions of the study are unfolded. The chapter ends by expanding the conclusion with some updates on the development of the implementing measure, energy and ecolabels and the technological development since the analysis was performed from 2009 to 2011.

## 4.1. SUMMARY OF THE ANALYSIS

The implementing measure for televisions was adopted in 2009 and the scope is televisions, including television monitors[3] and television sets[4] (European Commission, 2009).

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[3] A television monitor is defined as, 'a product designed to display on an integrated screen a video signal from a variety of sources, including television broadcast signals, which optionally controls and reproduces audio signals from an external source device, which is linked through standardised video signal paths including cinch (component, composite), SCART, HDMI, and future wireless standards (but excluding non-standardised video signal paths like DVI and SDI), but cannot receive and process broadcast signals' (European Commission, 2009, Article 2.3).

[4] Television sets are defined as, 'a product designed primarily for the display and reception of audiovisual signals which is placed on the market under one model or system designation, and which consists of (a) a display and (b) one or more tuner(s)/receiver(s) and optional additional functions for data storage and/or display such as digital versatile disc (DVD), hard disk drive (HDD) or videocassette recorder

### 4.1.1. FROM PREPARATORY STUDY TO IMPLEMENTING MEASURE

The timeframe from the launch of the preparatory study to the adoption of the requirements and coming into force of the requirements, was approximately four years. The preparatory study on LOT 5 Consumer Electronics: TV was launched in February 2006 and the final report was published in August 2007. The implementing measure was adopted as Commission Regulation (EC) No. 642/2009 of 22 July 2009, and the various requirements step into force in several steps (European Commission, 2009). The timeline for the adoption and implementation of the implementing measure is illustrated in Figure 11.

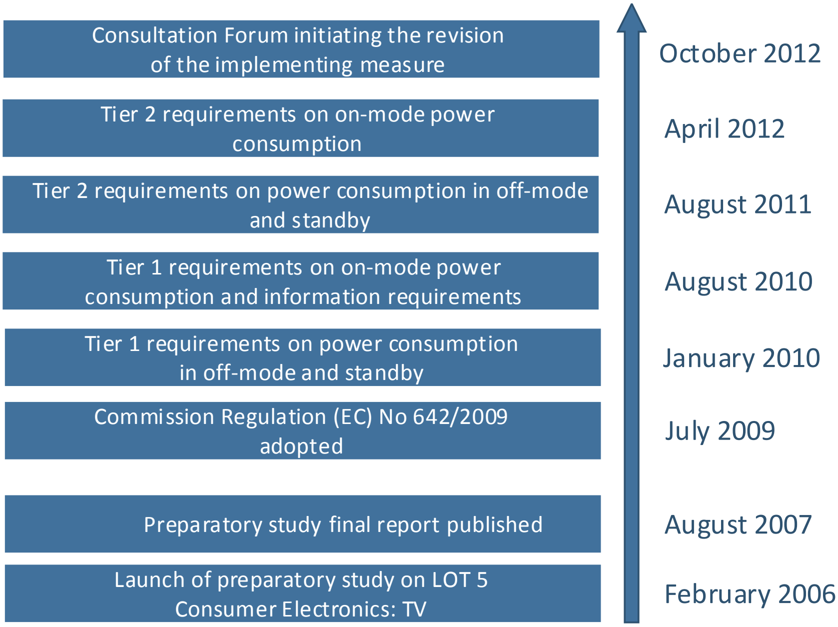


*Figure 11: Timeline for the adoption of the implementing measure for televisions.*

Before proposing ecodesign requirements, the technical parameters, which influence the environmental impact of the product, were analysed in the preparatory study. In particular, the different display technologies and screen sizes are significant, when measuring a television's environmental impacts. The study differentiated between 'self-emissive displays', such as Cathode Ray Tubes (CRT) and Plasma Panel Display (PDP) and 'non-self-emissive displays' such as Liquid Crystal Display

(VCR), either in a single unit combined with the display, or in one or more separate units' (European Commission, 2009, Article 2.2).

(LCD) and Rear Projection (RP). In the study's analysis of best available technologies, several other technologies were mentioned, among others the light emitting diodes (LED) technology. However, the study found that LED technology is accompanied with high cost, and that it is difficult to draw precise conclusions on the power consumption based on the available LED backlight products. The technology was therefore assessed to be immature. The 3D technology and the hot cathode fluorescent lamp (HCFL) technology, which are applied in the televisions analysed in section 4.1.3, were not mentioned in the preparatory study (Stobbe, 2007c).

Based on this analysis, two base cases were selected for further studies. These were a 32" LCD television and a 42" PDP television. The base cases were selected based on expected future sales. Thus, the CRT and RP technologies were less important for the preparatory study as the CRTs were being phased out and the RP was not considered to have a growing market as were the LCD and PDP technologies (Stobbe, 2007).

#### 4.1.1.1 Ecodesign Requirements in the Preparatory Study and the Implementing Measure

The focus areas of the proposed ecodesign requirements in the preparatory study and the actual requirements in the implementing measure are illustrated in Table 5. The power consumption in the use phase is, according to the preparatory study, the primary environmental impact of televisions. The reason is the increased power consumption of the European households, which is assessed to be increasing because of the increasing number of televisions in households; the introduction of flat panel display technologies; the higher resolutions and picture quality and the increasing screen sizes (Stobbe, 2007b). A few other areas were also identified as having an influence on the environmental impact of television sets. For full details on these requirements, please see Appendix B. These were, however, considered as a secondary focus, which is illustrated by placing them in brackets in Table 5.

*Table 5: Focus areas of the implementing measure compared to the recommendations of the preparatory study. Based on (Stobbe, 2007b and European, Commission 2009).*

| **Preparatory Study** | **Implementing measure** |
|---|---|
| Power consumption in on mode | Power consumption in on mode |
| Power consumption in off mode | Power consumption in off mode |
| Power consumption in passive standby | Power consumption in passive standby |
| Power consumption in active standby low | |
| (Introduction of an energy efficiency label) | |
| (When setting generic ecodesign requirements the *standard ECMA 341 – Environmental Design Considerations for ICT* and *CE Products or IEC 62430 – Environmentally conscious design for electrical and electronic product* is considered) | |
| (Chemicals in products) | |
| (Green procurement procedures should be applied) | |
| (Environmental information should be made available to consumers and the recycling industry) | Environmental information should be made available to consumers and the recycling industry |

In line with the primary focus of the preparatory study, the implementing measure focuses solely on power consumption, and it adds some information requirements on peak luminance. The only requirement in the implementing measure not related to power consumption is a requirement for information on the content of lead and mercury in the television, which concerning mercury, is recommended in the preparatory study. The reasons for this focus are presented in the comments to the Regulation. Here, it is emphasised that the preparatory study assessed that power consumption in the use phase is the cause of the relevant environmental impact.

Furthermore, environmental impacts related to hazardous substances in the televisions and waste from disposed televisions are not addressed by the regulation, as this is addressed in the RoHS Directive and the WEEE Directive, respectively. Additionally, it is stated that the Regulation should not benchmark the best available technology, as this is addressed in the European Ecolabel (European Commission, 2009).

#### 4.1.1.2 Requirements for On Mode Power Consumption

The recommendation of the preparatory study for minimum on mode power consumption requirements is expressed in an equation, taking into consideration the screen size, and a constant for the power consumption of the receiver. Additionally, another constant can be added in case the television set includes additional features, such as digital tuner or DVD/VDR. The recommendations differentiate between High Definition (HD) ready and full HD due to the novelty of the full HD technology (Stobbe, 2007b).

The requirement for on mode power consumption in the implementing measure is, as recommended, expressed in an equation, which consists of some of the same elements as the recommended equation. The differences in the recommendation of the preparatory study are that the unit is $dm^2$ instead of square inches, and that the requirement differentiates between television sets and monitors, instead of adding a constant value. In Figure 12, the recommended and actual requirements for on mode power are illustrated.

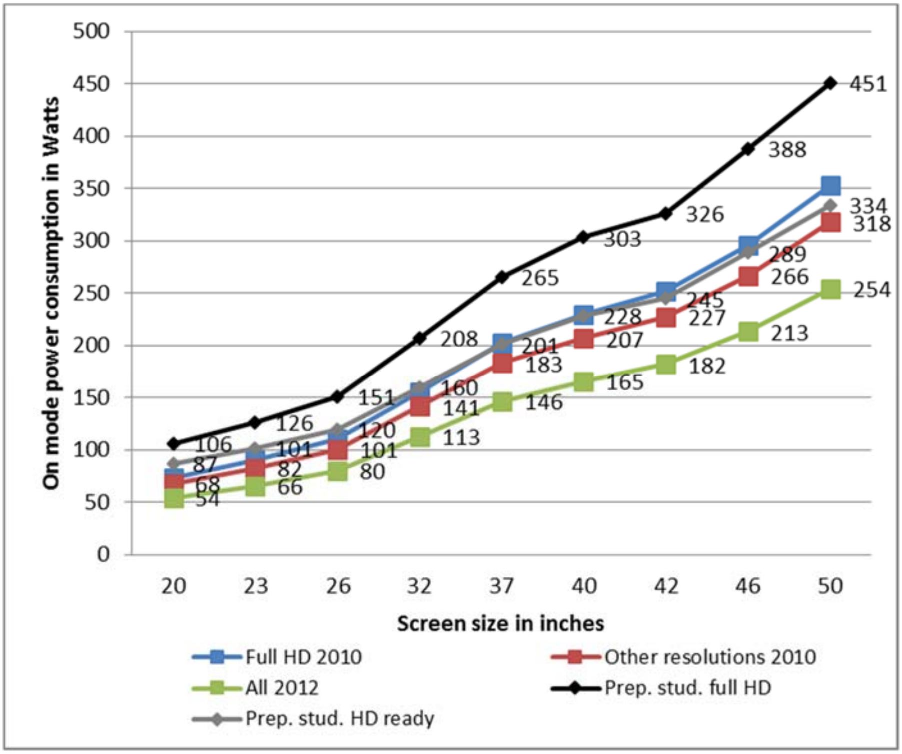


*Figure 12: On mode power consumption requirements compared to the recommendations of the preparatory study. Based on Stobbe, 2007b; European Commission, 2009, Annex 1.*

As illustrated in Figure 12, the implementing measure has tightened the requirements compared to the recommendations in the preparatory study. The implementing measure seems to be inspired by the ecolabels in that the constants for the 2010 requirements are the same as in the European Ecolabel and the Nordic Ecolabel (see Appendix B). In the 2012 requirement, the constants are lower leading to stricter requirements. Comments from stakeholders concerning lowering the constant from 40W to 15-20 W have also been heard (Stobbe, 2007c).

Besides the on mode power consumption requirement, the preparatory study recommended applying the IEC 62087 dynamic broadcast-content video signal test method for on mode power, and that a ‘standard mode’ should be defined, including directions on, for instance, how brightness and contrast should be defined, and this mode should be used during measurements (Stobbe, 2007b). The requirements in the implementing measure follow these recommendations in that additional requirements are set up for televisions with a forced menu[5] and peak luminance of the television (see Appendix B).

#### 4.1.1.3 Requirements for Off Mode and Standby Power Consumption

The requirements in the implementing measure for off mode and standby power consumption are to some degree aligned with the recommendations of the preparatory study. One important difference is that the implementing measure defines only one standby mode in contrast to the two standby-modes defined in the preparatory study. The requirement for standby is aligned with the recommended requirement for passive standby, which indicates that the standby requirements of the implementing measure are slightly stricter than what is recommended by the preparatory study. Regarding the requirement for power consumption in off mode, the implementing measure is, however, less strict than recommended. Finally, the recommendation on an automatic power down function was followed in the implementing measure, and a requirement on a ‘home-mode’ for televisions with a forced menu was added. The details on the requirements are listed in Table 3.4 in Appendix B.

### 4.1.2. COMPARISON WITH ECO- AND ENERGY LABELS

In this section, the requirements of the implementing measure are compared to the requirements of five different eco- and energy labels. The aim is to understand, where the labels have ‘set the bar’ for what is considered environmentally friendly. The reasons for using eco- and energy labels as a level for what is considered environmentally friendly is twofold: Ecolabels are acknowledged by authorities, consumers and producers, and secondly, many years of experience and work are behind the labels, and products fulfilling the label criteria are among the best environmentally performing products without compromising the quality. In Table 6, the types of requirements in the different energy, ecolabels and the implementing measure are illustrated. For a more detailed description of the eco- and energy labels and each requirement, please see Appendix B and D.

The narrow focus of the implementing measure for televisions is evident from the comparison in Table 6. All labels except the Energy Star and the Energy Label, which are specific energy labels, include requirements to dismantling, life-time extension and chemicals, therefore setting requirements to several phases of the product’s life cycle and to a wider number of environmental aspects.

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[5] Forced menu is in the implementing measure defined as, ‘a set of television settings pre-defined by the manufacturer, of which the user of the television must select a particular setting upon initial start-up of the television’ (European Commission, 2009).

*Table 6: Comparison of the types of requirements in the implementing measure and ecolabels. Based on European Commission, 2009, Annex 1; European Commission, 2009b; Nordic Ecolabelling, 2009; Energy Star, 2009; Rudling & Nordin, 2007.*

| **Subject** | **Implementing measures** | **European Ecolabel** | **Nordic Ecolabel** | **Energy Star** | **TCO'06** | **Energy label** |
|---|---|---|---|---|---|---|
| Energy efficiency index | | | | | | ■ |
| Power consumption in on mode | ■ | ■ | ■ | ■ | | |
| Power consumption in off mode | ■ | | ■ | | | |
| Power consumption in passive standby | ■ | ■ | ■ | ■ | ■ | |
| Power consumption in active standby low | | | | ■ | | |
| Maximum energy consumption | | ■ | ■ | ■ | | |
| Dismantling | | ■ | ■ | | ■ | |
| Life-time extension | | ■ | ■ | | | |
| Chemicals in products | | ■ | ■ | | ■ | |
| Environmental management system | | | | | ■ | |
| Information requirements | ■ | ■ | ■ | ■ | ■ | |

Taking a closer look at the requirements for on mode power consumption, Figure 13 illustrates that the implementing measure, as expected, is not as strict as the ecolabels. For example, televisions complying with the implementing measure requirements for full HD, is allowed to have an on mode power consumption that is 1.7 times higher than televisions complying with the European Ecolabel criteria for 2009. Televisions complying with the 2012 requirement in the implementing measure can have an on mode power consumption, which is more than 1.5 times higher than the television complying with the European Ecolabel criteria for 2011. In contrast to the European and the Nordic Ecolabel, which set a maximum power consumption requirement of 200 W, and the Energy Star, which set a maximum power consumption requirement of 108 W as of May 2012, the implementing measure does not set an upper limit. In this way, the implementing measure is accepting the direct relation between screen sizes and energy consumption, i.e. the bigger the screen size, the higher power consumption is allowed. This is problematic, as the overall goal of the Ecodesign Directive is to achieve energy savings and, therefore, should take the trend in increasing screen sizes into consideration (see Figure 4 in Chapter 1). As such, energy requirements dependent on screen size do not necessarily equal absolute energy savings, and the above described requirements involve a risk of rebound effects, where energy efficiency savings are levelled out by the increasing screen sizes. In a Danish context, this concern has proven correct. In Figure 3 in Chapter 1, increasing energy consumption from televisions in the period 2007 to 2012 is illustrated, despite the implementing measure for television being in effect. The European Commission's own figures also support this concern. In a brochure from 2010, the annual expected savings by 2020 related to televisions were 43 TWh, and only two years later the expectations were lowered to 28 TWh (European Commission, 2010b; European Commission, 2012).

Regarding the Energy Labelling Directive, due to the character of the energy efficiency index, which is divided in intervals, the lines in Figure 13 represent the maximum power consumption the television can have in order to obtain the given label. As an example, in order for the television to obtain the Energy Label A+ the television must have an on mode power consumption that is between the A+ line and the A++ line. The lowest possible energy efficiency level (G) is illustrated in Figure 13 as any product with a power consumption above the F level line.

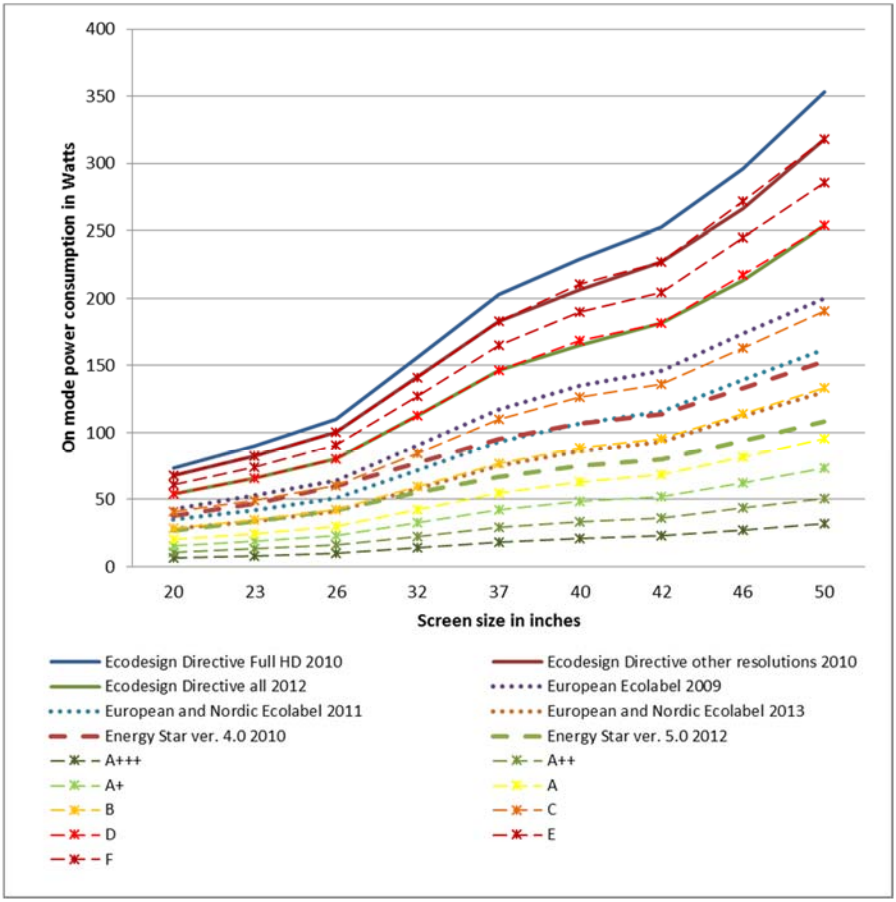


*Figure 13: Comparison of the on mode power consumption Requirements of the Energy Labelling Directive with the Ecodesign Directive and European Ecolabel. Based on European Commission, 2009, Annex 1; European Commission, 2009b; Nordic Ecolabelling, 2009; Energy Star, 2009; Rudling & Nordin, 2007; European Commission, 2010.*

That the requirements in the implementing measure are less strict than the ecolabels is not surprising, given that they are different types of policy instruments, as discussed in Chapter 3. Ecolabels are an incentive for frontrunner companies to get a competitive advantage on the market, whereas the implementing measure is minimum requirements aiming at excluding the worst performing products from the market. However, there is a large range between the requirements, especially regarding the larger screen sizes, and hence, it gives rise to the question whether the ambition level of the implementing measure could be raised.

The Energy Label covers all televisions from the most inefficient that cannot comply with the requirements of the implementing measure to the more efficient far better than the criteria in European Ecolabel. The role of the implementing measure as setting minimum requirements removing the worst performing products from the market and not as such promoting radical eco-innovation is also evident from Figure 13.

An interesting finding when comparing the energy efficiency index of the Energy Label to the ecolabels is that even the strictest European Ecolabel requirement applicable from 2013 is just equivalent to a B level of the energy efficiency index. However, the European Ecolabel should be applicable to only the best products, and it is, therefore, strange that the European Ecolabel has not been synchronised with the Energy Labelling Directive.

Based on a comparison of the requirements in Figure 13, it can be argued that where the implementing measure for televisions does not set strict ecodesign requirements, and thereby, fails in being a driver for eco-innovations of televisions, the energy-labelling scheme takes the lead and creates necessary incentives for producers to improve their products' energy efficiency. However, the focus of the Energy Label is solely on energy efficiency in on mode, and other significant environmental impacts are not addressed. Therefore, while the Energy Label might create incentives for producers to improve their television's energy efficiency, other measures are necessary to improve the environmental performance of televisions in a life cycle perspective.

### 4.1.3. COMPARISON WITH TELEVISIONS ON THE MARKET

Two groups of televisions were analysed in terms of what technologies exist and to what extent the televisions comply with the requirements of the implementing measure and the different labels, presented above. The focus was the on mode power consumption requirements; see Appendix B for an analysis of the remaining requirements. The first group is ecolabelled televisions, which were assessed to include best available technologies (BAT). They were analysed, as it was assumed that these televisions had no or only a few problems in complying with the requirements of the implementing measure and the different labels. The aim of the analysis of the first group of televisions was to point out what the actual potential was for lowering the environmental impact of televisions. The second group was non-ecolabelled televisions, as these televisions were expected to have the most difficulty in complying with the requirements of the implementing measure and the different labels. These televisions were analysed to find out the potential of the implementing measure to actually expel televisions from the market.

The analysis was performed in two steps. The first analysis was conducted in winter 2009/2010, approximately six months before the requirements of the implementing measure went into effect. A second analysis of the ecolabelled televisions was performed in spring 2011, which is approximately six months after the requirements of the implementing measure went into effect. By having this two-step approach, it was possible to assess the ambition level of the implementing measure, and thereby the Ecodesign Directive, and to assess how fast the technological development is.

Information about the specific televisions analysed is available in Appendix B. It is important to mention here, though, that specifically two technologies used by Samsung and Philips (LED) and Sony (HCFL), respectively, appear to have a significant positive influence on the environmental performance of the analysed televisions. Besides these technologies, all three producers have installed a number of features in the televisions, which reduce the power consumption even further. These is, for example, a presence censor, which detects body heat and movement, a light censor, which registers the light in the room and adjusts the backlight accordingly, an eco-mode, a picture mute (for radio) and an auto switch-off timer. (Sony, 2010; Philips, 2010; Philips, 2011; Samsung, 2011).

In Figure 14, the power consumption in on mode of the ecolabelled televisions is compared to the requirements in the implementing measure and the different labels. It is evident that all televisions perform significantly better than what is required by the implementing measure. Three of the televisions from the 2011 analysis even comply with the Energy Star criteria for 2012, which is the strictest criteria. Figure 14 also illustrates that there has been a decrease in power consumption from the 2009/2010 analysis to the 2011 analysis, except for one Samsung television, which had an increased power consumption in 2011 compared to 2009/2010. Another interesting finding is that even though the 32” (57 W) and the 40” (60 W) from Samsung include the 3D technology, they are still able to comply with strictest European Ecolabel criteria (32”) and the strictest Energy Star criteria (40”). The 40” (130 W) television from Samsung also includes the 3D technology, but even though the power consumption is higher than the other 40” television from Samsung, it can still easily comply with the requirements of the implementing measure. Finally, it is worth noticing that the 40” (60 W) television from Samsung and the 42” television from Philips have a power consumption that is less than half of the power consumption of other 40” televisions, which implies that screen size does not need to be a determinant for the power consumption of the television.

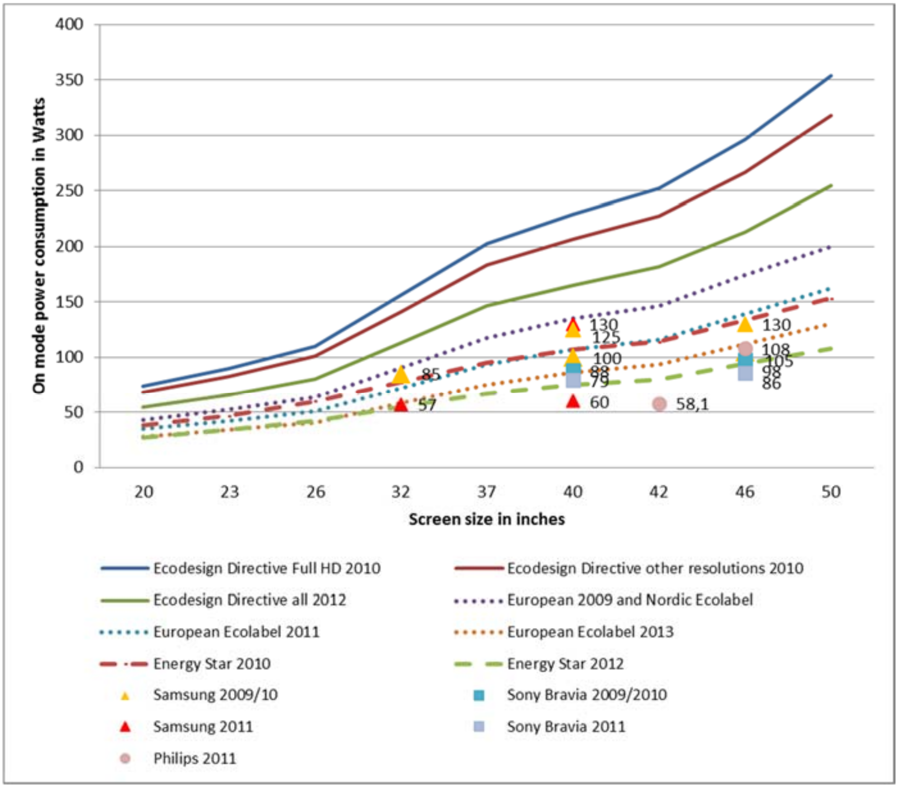


*Figure 14: The on mode power consumption of the ecolabelled televisions compared to the requirements of the implementing measure and the different labels. Based on European Commission, 2009, Annex 1; European Commission, 2009b; Nordic Ecolabelling, 2009; Energy Star, 2009; Rudling & Nordin, 2007; Samsung Electronics Nordic AB, n.d.; Samsung, 2010; Samsung, 2011; Sony, 2010; Sony, 2011; Philips, 2011b.*

In the preparatory study, the LED technology was mentioned, but the authors of the study assessed it to be too immature to be able to draw conclusions on its power consumption level. It was, therefore, assumed that the technology did not influence the process of establishing the requirements. Neither the HCFL nor the 3D technologies could have had any influence on the preparatory studies as these technologies were not mentioned in the studies. This analysis, however, revealed that the technological development happened faster than expected in the preparatory study, and it is evident from Figure 14 that the fact that the LED and HCFL technologies have had an influence on the power consumption of the televisions. It is not surprising, though, that LED technology was not part of the analysis in the preparatory study as the LED technology was not on the market when the preparatory studies where initiated. On this basis, it can be concluded that the technological development happened significantly faster than what was expected by the legislators, and that the process of developing and adopting the requirements for on mode power consumption must have been too slow to incorporate this fast technological development. As a consequence, the environmental improvement of the televisions regarding on mode power consumption appears to be driven more by a technology push rather than a regulatory push. Of course, there is the possibility that the technological development happened this rapidly because of the anticipation of the coming regulation. However, the difference between the requirement level and the performance of the television is significant, and it must be questioned if a shorter requirement development and adoption process or better technology forecasting should have detected the importance of including these technologies in the preparatory studies.

Another interesting finding is that the Sony televisions with the lowest on mode power consumption in the 2011 analysis were not the ecolabelled televisions. This could lead to the conclusion that not even the ecolabels can keep up the pace on the technological development.

In Figure 15, the power consumption in on mode of the non-ecolabelled televisions is compared to the requirements in the implementing measure and the different labels.

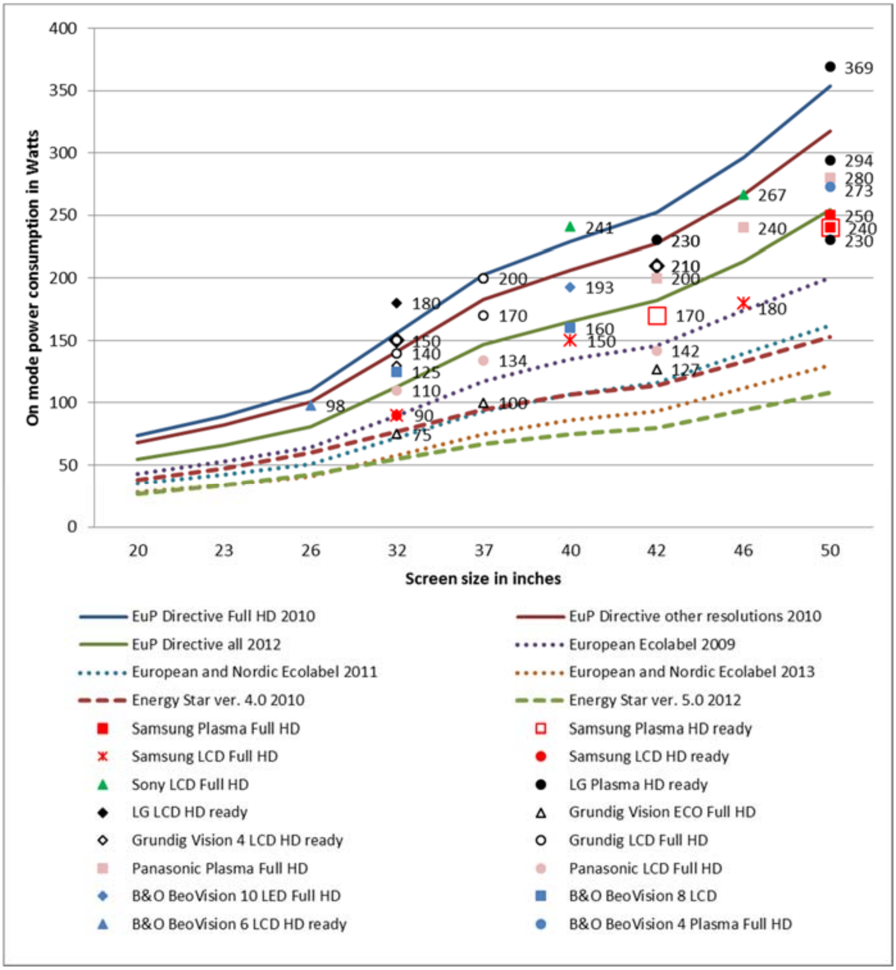


*Figure 15: The on mode power consumption of the non-ecolabelled televisions compared to the requirements of the implementing measure and the different labels. Based on European Commission, 2009, Annex 1; European Commission, 2009b; Nordic Ecolabelling, 2009; Energy Star, 2009; Rudling & Nordin, 2007; LG Electronics 2010; Grundig, 2010; Grundig, 2010b; Panasonic Europe Ltd., 2010; Sony, 2010; Samsung, 2010; B&O, 2010.*

It is evident that all the analysed televisions from Samsung, Grundig, Panasonic and B&O complies with the implementing measure applicable from 2010. For Samsung, the Ecovision from Grundig, the LCD televisions from Panasonic and B&O's 40" BeoVision 8 comply, even with the requirements applicable from 2012.

The requirements also provide challenges for some of the televisions. Sony's 40" television cannot comply with any of the requirements, and the 46" television can comply with the 2010 requirements of the implementing measure. For LG's televisions, the requirements are also a challenge. Only one (the 50” 230 W) of the four analysed plasma television complies with the 2012 requirement of the implementing measure, and two comply with the 2010 requirement (the 50” 230 W and 294 W). For the LCD televisions from LG, the two 32” (180 W and 150 W) are not in compliance with any of the requirements. Regarding the 42” televisions, one is in compliance (the 210 W) and one (the 230 W) is not in compliance with the 2010 requirement of the implementing measure.

As is illustrated in Figure 15, the implementing measure did remove some products from the market, but is also an interesting finding that already six months before the 2010 requirements of the implementing measure came into effect, 46% of all analysed televisions are in compliance with the requirements applicable from 2012. Of the analysed televisions, 89% are in compliance with the 2010 requirements of the implementing measure and only 11% cannot comply with any of the requirements.

## 4.2. LOW AMBITION LEVEL

One conclusion drawn from the case study of the implementing measure for televisions is that the ambition level in the implementing measure for televisions is low, concerning both the focus areas of the requirements and the level of the individual requirements.

From the launch of the preparatory study to the final requirements in the implementing measure, there has been a narrowing of the focus areas to merely include requirements to energy consumption in the use phase and an information requirement on the content of lead and mercury. Even though the preparatory study underlined that power consumption in the use phase is the most significant impact, it did recommend using ecodesign standards, e.g. *ECMA 341*, applying green procurement procedures and including environmental information on chemicals, among other issues as well. As presented in chapter 3, the Ecodesign Directive takes a comprehensive viewpoint on ecodesign and as such provides the potential for comprehensive ecodesign requirements. Analysing the different ecolabels it was concluded that it is possible to set up requirements, which take more environmental areas and life cycle phases into consideration. The reasons given for this narrow focus is that, as mentioned in section 3.5.1, only the most important environmental impacts are addressed and environmental impacts related to hazardous substances in the televisions and waste from disposed televisions are addressed in the RoHS Directive and the WEEE Directive, respectively. On this basis, it was concluded that the implementing measure has a low ambition level concerning the focus areas in scope. On the positive side, though, it should be mentioned that due to the planned continuous update of the requirements, in time, as the power consumption decreases, other environmental aspects become more important. This process might take several years, though.

It was also concluded that the level of the on mode power consumption requirement, especially, is too low, even though they have been tightened since the preparatory study. This is visible in a comparison of the requirements in the implementing measure to the requirements in the different eco- and energy labels; the ecolabels set significantly stricter requirements. The fact that the ecolabels set significantly stricter requirements than the implementing measure is only logical, as they are two different types of policy instruments, as explained in Chapter 3. The implementing measure set minimum requirements aimed at expelling the worst performing products from the market, whereas the ecolabel set strict requirements targeting the frontrunner companies. What is alarming is how large the difference is between the two. Furthermore, looking at the Energy Label, it appears that even the strictest requirement in the implementing measure only corresponds to a D label. In addition, the requirements in the implementing measure are accepting the relation between screen size and power consumption, which does not automatically lead to absolute power savings due to the trend in larger screen sizes. The analysis of the ecolabelled televisions, however, clearly illustrated that the screen size does not need to be a determinant for the on mode power consumption of television, but that this is the case in the majority of the televisions. The ecolabels have considered such rebound effects by setting a maximum requirement for power consumption in on mode regardless of screen size. The analysis of the ecolabelled televisions also concluded that the implementing measure does not reflect the performance level of new technologies, such as LED and HCFL, as all the analysed ecolabelled televisions have significantly lower power consumption than what is required. Furthermore, even the study of the non-ecolabelled televisions shows high compliance rates even before the requirements come into effect, which also indicates a low ambition level.

One reason for this low ambition level appeared to be the lengthy process of developing the requirements, which was a four year process. Since the preparatory study was completed, certain technologies have gained importance on the market, which have not been given the necessary attention in the study. In particular, the LED technology used as a backlight system in LCD televisions is relevant to analyse in depth, as this technology has significantly improved the energy efficiency compared to PDP and traditional LCD technology. Therefore, the requirements seemed outdated almost before they came into force. As mentioned in Chapter 3, the evaluations of the Ecodesign Directive in both 2012 and 2013/2014 agree with this conclusion, and the television case is even highlighted as the worst-case example of the slow requirement development process, and of the preparatory study not being able to anticipate the technological development. Furthermore, as mentioned in Chapter 3, the 2012 evaluation of the Ecodesign Directive concludes that the energy efficiency improvements of televisions cannot be directly linked to the implementing measure, but it may be the case that the implementing measure has enhanced the trend.

On this basis, it was concluded that where the implementing measure fails in being a driver for eco-innovation—in that only minimum requirements are set up—the Energy Label can take the lead and create necessary incentives for the producers to improve the energy efficiency of the televisions. However, as the Energy Label merely focuses on energy in the use phase, it is still necessary with comprehensive ecodesign requirements in the implementing measure in order to address other environmental aspects and life cycle phases.

## 4.3. TOO LITTLE INTERPLAY BETWEEN POLICY INSTRUMENTS

A second conclusion, which was drawn from the case study of the implementing measure for televisions, is that in the period of preparing the implementing measure for televisions there was too little interplay between the Ecodesign Directive, the implementing measure, and especially, the ecolabels and energy labels.

In section 4.1.1 it appeared that the ecolabels have merely served as inspiration for the requirements to on mode power consumption after the preparatory study is completed. The development of the ecolabel criteria and the implementing measure took place independent of each other. As such, a large, unfulfilled potential was identified in co-developing the criteria among the different labelling schemes and the implementing measure of the Ecodesign Directive, for instance, through a common information platform. This could improve the long development time from the launch of the preparatory study and the adoption of the implementing measure, and possibly, it could imply a better forecasting of the technological development, because the time horizon is shorter.

The analysis of the performance of the televisions on the market related to the European and Nordic Ecolabel revealed that in the case of Sony in the 2011 analysis, it was the televisions without an ecolabel that have the lowest on mode power consumption. Furthermore, many of the ecolabelled televisions, especially in the 2011 analysis, had a significantly lower on mode power consumption than the requirements in the ecolabels. This indicates that these ecolabels are not able to keep up the pace with the technological development, either. This is problematic, as particularly the ecolabels, as introduced in Chapter 3, are supposed to include requirements that only the best performing television on the market can comply with.

## 4.4. EXPANDING THE ANALYSIS WITH RECENT DEVELOPMENTS

Since the analysis presented in the above was conducted in 2009–2011, technological development has moved further than expected in the analysis, and the implementing measure is now under revision. Hence, this section focuses on these developments and what they entail for the conclusion of the case study of the implementing measure for televisions.

### 4.4.1. REVISION OF THE IMPLEMENTING MEASURE AND ENERGY LABEL FOR TELEVISIONS

In accordance with the implementing measure for television, Commission Regulation (EC) No 642/2009 of 22 July 2009, Article 6, the consultation forum for reviewing the implementing measure was held in October 2012, which was no later than three years after its adoption. It was decided to merge this revision with the work on the draft regulation on display products, due to, among other things, the increasing convergence of these products. Furthermore, the review should take place simultaneously with the review of the Energy Label for televisions, with the aim of preparing one set of ecodesign and energy labelling requirements for all electronic displays, including televisions, computer monitors and digital photo frames (Consultation Forum, 2012).

The review process is still on-going, and the latest proposal was presented at the Consultation Forum in December 2014. The main differences from the regulation currently in force are (European Commission, 2014):

- **New scope**: The regulation establishes ecodesign requirements of electronic displays, which include but are not limited to televisions, including hospitality televisions, computer displays and digital photo frames.
- **Logarithmic equation**: The on mode power consumption requirement is based on a logarithmic equation instead of a linear equation.
- **Networked standby**: Networked standby requirements are added.
- **Resource efficiency**: Resource efficiency requirements are added.

Concerning the Energy Label, modifying the classification of the energy efficiency index has been proposed, by tightening the requirement to avoid overcrowding of the top classes of the label, i.e. A+ to A+++. This is assessed to extend the lifetime of the label until the overall label update is complete, which should take place no later than 2015. At that point, it is noted that the equation in the label should also be modified, but is assessed to be disproportionate at this point in time. Furthermore, the three lowest energy classes E-G are banned (European Commission, 2014b).

In the revision, the grounds for the proposed changes are emphasised to be both the changes in the market, and the regulatory gaps and market failures of the regulation currently in force. In the period 2007 to 2013 there was a technological shift from analogue to digital broadcast, a change in size ratio from 4:3 to 16:9, an increase in resolution from HD to full HD to UHD, and finally, the introduction of flat screens. Over the same period of time, a tendency towards buying larger screen sizes was visible (European Commission, 2014b).

#### 4.4.1.1 New Scope and Logarithmic Equation

By changing the scope of the regulation, the so far non-regulated displays are included in the scope, and the rapidly progressing convergence between displays is taken into account, closing possible regulatory gaps. Acknowledging that the regulation currently in force has had no direct influence on the technological development and energy savings in the television market, a *logarithmic equation* instead of a *linear equation* and a tightening of the requirements is proposed. In doing so, the proposal aims at reflecting the technological development more appropriately (European Commission, 2014b). In Figure 16, the proposed on mode power consumption requirements are compared to the requirement currently in force.

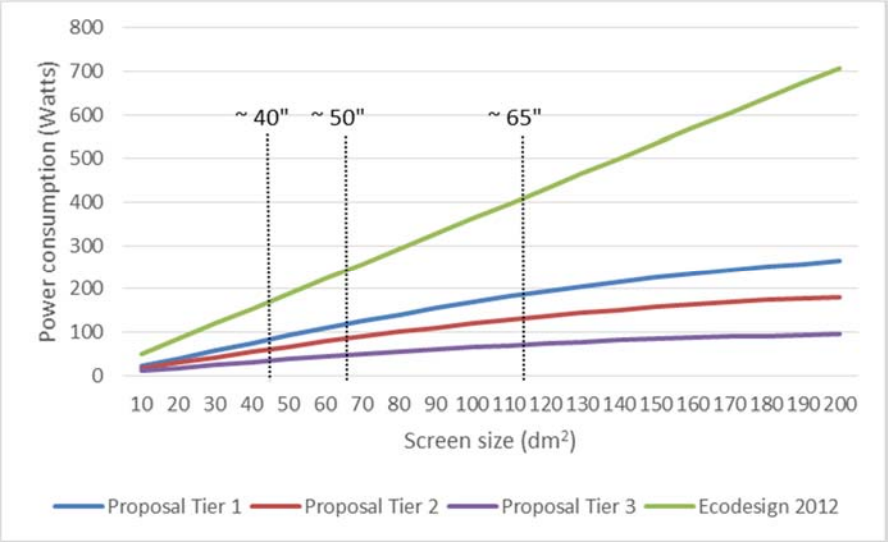


*Figure 16: Proposed on mode power consumption requirements and the requirement currently in force. Based on European Commission, 2014; European Commission, 2009.*

#### 4.4.1.2 Networked Standby

By including requirements for networked standby, the proposal aims at addressing new energy-intensive features, and since the proposal includes requirements for standby, networked standby and off mode power consumption, the following implementing measures should no longer apply to electronic displays, and should be amended accordingly (European Commission, 2014):

- Commission Regulation (EC) No. 1275/2008 of 17 December 2008 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for standby and off mode electric power demand of electrical and electronic household and office equipment.
- Commission Regulation (EU) 801/2013 of 22 August 2013 amending Regulation (EC) No. 1275/2008 with regard to ecodesign requirements for standby, off mode electric power consumption of electrical and electronic household and office equipment, and amending Regulation (EC) 642/2009 with regard to ecodesign requirements for televisions.

#### 4.4.1.3 Resource Efficiency

The proposed resource efficiency requirements are information requirements aimed at helping recyclers to better comply with the WEEE Directive, and concern the manufacturers' responsibility to a) disclose information relevant for disassembly, recycling and/or recovery at end of life, b) marking of plastic parts, c) declaration of the recyclability rate of plastic parts, and d) label for mercury and BFR presence (European Commission, 2014b).

### 4.4.2. UPDATES ON THE ECOLABELS

The ecolabels and Energy Star Label are also in the process of being revised. The European Ecolabel—criteria used in the analysis in section 4.1.2—were originally intended to expire in October 2013. However, the criteria were prolonged until December 2015. The criteria are currently undergoing revision, and the newest criteria draft and technical report are from October 2014 (Joint Research Centre, 2014). Worth noticing is that the scope of the criteria appears to be broadened to cover electronic displays, which is in line with the proposal for implementing measures for televisions. The definitions of electronic displays in the two proposals are, except a few formulations, identical (Garrido et al, 2014).

The Nordic Ecolabel updated the requirements for televisions in June 2015 and they are valid until March 2017. Both the European and Nordic Ecolabel now refer to the Energy Label concerning the requirement for on mode power consumption. The Nordic Ecolabel requires an A+ label for all televisions, whereas the European Ecolabel requires either A (smaller screen sizes), A+ or A++ (larger screen sizes) depending on screen size. Furthermore, the European Ecolabel proposes a maximum power consumption of 64W regardless of screen size. This is no longer included in the Nordic Ecolabel (European Commission, 2014c; Nordic Ecolabelling, 2013).

The Nordic Ecolabel in the updated version refers to the implementing measure currently in force for televisions regarding requirements to standby and off mode, whereas the proposal for the European Ecolabel has skipped the previous requirement to passive standby and set up a requirement for networked standby power consumption. Furthermore, the European Ecolabel proposes requirements for both manual and automatic brightness control, which impacts the power consumption of the televisions. Both labels have expanded the criteria for areas not related to power consumption. The European Ecolabel has, for instance, added CSR requirements on, for example, sourcing of conflict minerals, requirements for recycled content, and has extended the link to the REACH Regulation concerning hazardous substances. The Nordic Ecolabel, for instance, has added requirements on, for example, recycled materials in packaging and phthalates in power cables (European Commission, 2014c; Nordic Ecolabelling, 2013).

The version of the Energy Star Label currently in force is version 6.1, which will be replaced by version 7.0 in October 2015. Since version 6.1, the Energy Star Label has adopted a logarithmic equation in line with the proposal for the implementing measure for electronic displays (Energy Star, 2014; Energy Star, 2014b). In Figure 17 the proposed changes to the Energy Label and the Energy Star Label are compared to the currently in force criteria. The lines in Figure 17 representing the Energy Label represent the maximum power consumption that the displays can have in order to obtain the given label. As an example, in order to obtain the label A++, the display must have an on mode power consumption that is between the A++ line and the A+++ line. The lines representing the A label and lower are not illustrated, as these are not changed compared to Figure 13.

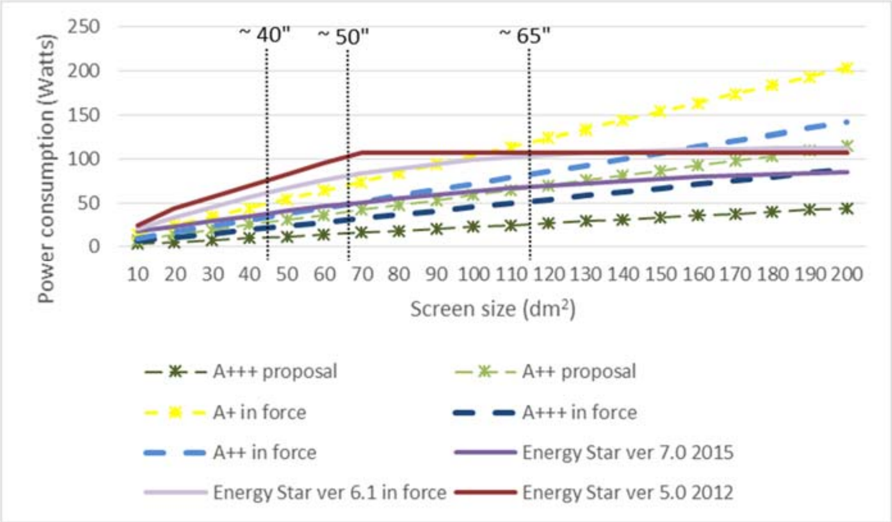


*Figure 17: The proposed changes in the Energy Label and Energy Star. Based on European Commission, 2010; European Commission, 2014d; Energy Star, 2009; Energy Star, 2014; Energy Star, 2014b.*

### 4.4.3. UPDATES ON THE TELEVISIONS ON THE MARKET

Regarding an update on the performance of the televisions on the market, the analyses conducted by topten.eu are useful. Topten.eu is an online search tool targeted to consumers and large buyers and is focused on presenting the best appliances in various categories, the key criteria being energy efficiency, impact on the environment, health and quality (topten.eu, 2015). In 2014 a report covering the European televisions market in the period 2007–2013 was published, which focused specifically on the energy efficiency of televisions before and during the implementation of the Ecodesign and Energy Labelling Directives. The report, therefore, serves as an update on the case study of televisions, presented in the above. The report highlights some of the same points as in the above analysis. First, two technological shifts happened from 2007 to 2010 (see Figure 18).

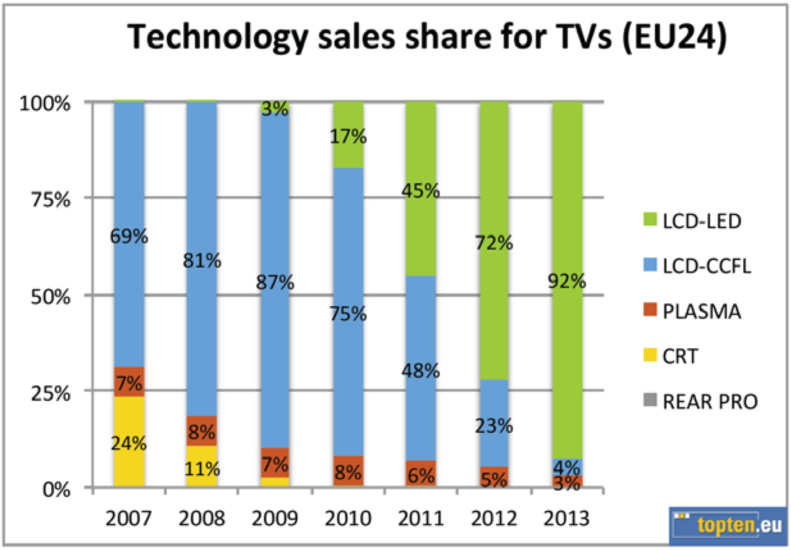


*Figure 18: The technology sales share for televisions in the period 2007 to 2013 (Michel, Attali & Bush, 2014).*

From Figure 18 it appears that the LCD-LED technology has gained significant market shares; that the CRT technology has disappeared completely from the market; and that the plasma and LCD-CCFL have decreased their market shares significantly. The report also highlights on mode power consumption reductions of 65% across all screen sizes, and the larger screen sizes (40”–50”) as high as 72%. However, in line with the analysis presented in the above, the Topten report argues that these energy savings were a result of technology development rather than a direct influence of the Ecodesign or Energy Labelling Directives. It is argued, though, that the Ecodesign and particularly the Energy Labelling Directive have most likely accelerated the process (Michel, Attali & Bush, 2014). In Figure 19 the average on mode power consumption of 40”–43” televisions are compared to the ecodesign requirements for a 41.5” television are illustrated as an example of how far apart the ecodesign requirements are compared to the performance of the televisions on the market.

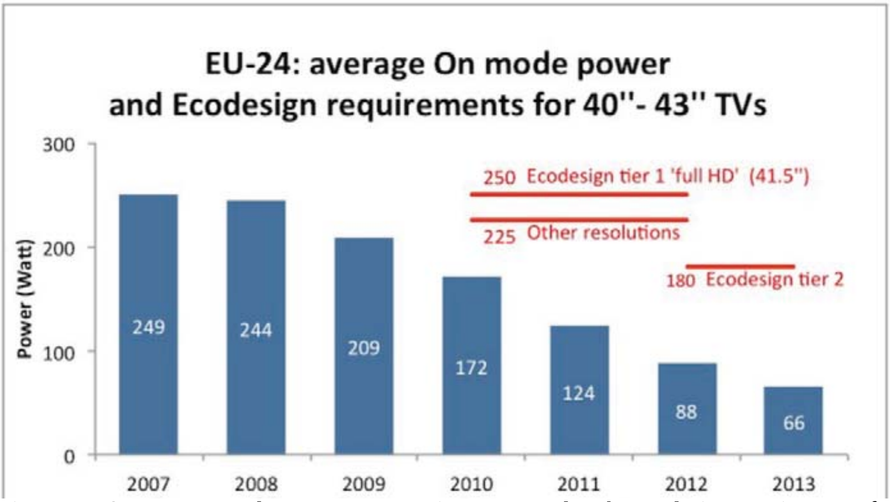


*Figure 19: Average on mode power consumption compared to the ecodesign requirements for a 41.5” television (Michel, Attali & Bush, 2014).*

The Topten report also reveals a sales peak on televisions, which reached its maximum before the ecodesign requirements were in force and, therefore, also before energy efficiency gains could make up for the increased screen sizes, functionalities and number of televisions. The report, therefore, underlines the importance of looking at absolute consumption or taking a progressive or capped approach, which would not support the trend to larger screen sizes. This is in line with the proposal for ecodesign requirements for electronic displays, as presented in section 4.4.1 (Michel, Attali & Bush, 2014).

## 4.5. CONCLUSION

Many of the points of criticism mentioned in sections 4.2 and 4.3 have been taken into consideration in the revision of both the implementing measure and the revisions of the eco- and energy labels. The on mode power consumption requirement has been tightened and is based on a logarithmic equation, which does not favour the large screen sizes, and is a step towards securing not only energy efficiency gains but absolute energy savings as well.

The fact that focus in the proposal for the revised implementing measure specifically includes resource efficiency aspects must be seen as a result of and in line with the general change in focus in the EU, as presented in Chapter 3, where resource efficiency is now part of the political agenda. Even though the regulation currently in force is not the only cause, the energy efficiency of televisions has increased, and other environmental impacts will, in time, grow in importance. The resource efficiency focus of the EU is also visible in the revisions of the ecolabels, which have both included or proposed more resource efficiency requirements.

The interplay between the implementing measure, the Energy Label and the different voluntary ecolabels has also improved. The proposed scope of the European Ecolabel and of the proposal for the implementing measure are close to identical—both ecolabels refer to the Energy Label for on mode power consumption, and the implementing measure, the Energy Label and the European Ecolabel are revised at the same time. These are all examples of how the interplay has improved, and hopefully, this will contribute to, among other things, shorter processes for developing the requirements, and the discrepancy between the requirement levels will be corrected. In order to have a clear synergy between the different policy instruments, the distinction should be clear that the requirements in the implementing measure are minimum requirements and the European Ecolabel set requirements aimed at the frontrunner enterprises.

Assembling the conclusions of the original analysis from 2009–2011 and the conclusion based on the updated information, it is possible to answer the research question: *What are the achievements and ambitions of the Ecodesign Directive, based on the implementing measure for televisions?*

The first set of implementing measures for televisions did not have an ambition level corresponding to the fast technological development and as a result, the implementing measure had no direct influence on the efficiency gains. The influence was limited, but together with the Energy Label, it has most likely accelerated the pace of the technological development. The revision of both the implementing measure, the Energy Label and the ecolabels, however, reveal that many of the issues that have been criticised are now being taken into account—for instance, the tightening of the on mode power consumption and the inclusion of information requirements to resource efficiency.

The following chapter presents a paper published in the *International Journal of Life Cycle Assessment*. The paper includes a life cycle assessment of two televisions, and as such, the aim is to take a slightly different angle to the analysis of the implementing measure for televisions. The ecodesign requirements in the implementing measures have been set up following a specific methodology. Through an analysis of which life cycle phases and environmental impact categories are important when setting ecodesign requirements for televisions, the paper analyses whether the results of the methodology for setting ecodesign requirements for energy-using products are correct in stating that the most important impact is energy consumption in use phase.

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Sony. (2011) *Sony*. [online] Available from: http://www.sony.dk/section/startside [accessed 12th January 2011]

Stobbe, Dr. L. (2007) *EuP Preparatory Studies "Televisions" (Lot 5): Final Report on Task 1 "Definition"*. Compiled by Fraunhofer Institute for Reliability and Microintegration, IZM. Berlin: Fraunhofer IZM

Stobbe, Dr. L. (2007b) *EuP Preparatory Studies "Televisions" (Lot 5): Final Report on Task 8 "Scenario, Policy, Impact and Sensitivity Analysis"*. Compiled by Fraunhofer Institute for Reliability and Microintegration, IZM. Berlin: Fraunhofer IZM

Stobbe, Dr. L. (2007c) *EuP Preparatory Studies "Televisions" (Lot 5): Final Report on Task 6 "Technical Analysis BAT"*. Compiled by Fraunhofer Institute for Reliability and Microintegration, IZM. Berlin: Fraunhofer IZM

topten.eu. (2015) *About us.* [online] Available from: http://www.topten.eu/english/services/about_topten.html [accessed 8th September 2015]

# CHAPTER 5. PAPER: ECODESIGN REQUIREMENTS FOR TELEVISIONS: IS ENERGY CONSUMPTION IN THE USE PHASE THE ONLY RELEVANT REQUIREMENT?

This chapter contains a paper published by Springer in the International *Journal of Life Cycle Assessment*, Volume 18, 2013, pp. 1098-1105, Ecodesign requirements for televisions—is energy consumption in the use phase the only relevant requirement?, Rikke Dorothea Huulgaard, Randi Dalgaard and Stefano Merciai. It is reprinted here from http://link.springer.com/article/10.1007%2Fs11367-013-0554-8, with kind permission from Springer Science and Business Media.

In the paper, a life cycle assessment of two televisions conducted in 2010 is presented, and it is, as such, a continuation of the analysis in Chapter 4 from 2009–2011. The analysis takes a slightly different angle to the analysis of the implementing measure for televisions, which is based on a life cycle assessment analyses, to examine which life cycle phases and environmental impact categories are important when setting ecodesign requirements. The ecodesign requirements in the implementing measures have been set up following a specific methodology and the aim of the paper is to analyse whether the results of the methodology for setting ecodesign requirements for energy-using products are correct in stating that the most important impact is energy consumption in use phase. The research question that guides the analysis is:

*What life cycle phases and environmental impact categories are important when setting ecodesign requirements for televisions?*

# CHAPTER 6. CONCLUSION PART I

The Ecodesign Directive and the implementing measure for televisions was the focus of this first part of the thesis. The analysis was divided into three steps, this chapter contains the complete conclusion for Part I, and it answers the three research questions:

1. *What is the role and ambition of the Ecodesign Directive and how is it implemented in practice?*
2. *What are the achievements and ambitions of the Ecodesign Directive, based on the implementing measure for televisions?*
3. *What life cycle phases and environmental impact categories are important when setting ecodesign requirements for televisions?*

## 6.1. THE ECODESIGN DIRECTIVE: AMBITIONS AND PRACTICE

In Chapter 3, it was found that the Ecodesign Directive, through its status as a framework directive, provides the basis for setting up minimum requirements in the implementing measures aimed at removing the worst performing products from the market. As such, the ambition level of the Directive has not been the only driver for innovation. However, the Directive provides a comprehensive definition of ecodesign, which implies that it is possible to set ambitious ecodesign requirements in the implementing measures. Analysing the adopted implementing measures, the implementation of the Directive through the implementing measures has narrowed the ambition level, and in practice, requirements concerning energy in the use phase are mainly set up.

The reasons for the reduced ambition level in the implementing measures appeared to be a combination of the following: the initial scope of the Directive, namely, energy-using products; the methodology applied for establishing the requirements; significant improvement potential is not dealt with; and only most significant environmental impacts are included in the requirements. Chapter 3 also revealed that the implementation of the Directive is being criticised for having an ambition level that is too low concerning the individual requirements; one explanation is the long process for developing them. On this basis, it was concluded that the ambition of the Ecodesign Directive, despite its aim of merely setting minimum requirements, is to allow comprehensive ecodesign requirements in the implementing measures. It is in the implementation of the Directive through the implementing measures that it becomes visible that the full potential has not been reached.

Besides, the interplay with other policy instruments could be strengthened in order to drive the technological development and promote BAT and innovation. The link between the Ecodesign Directive and the Energy Label is clear through their focus on energy, but if other environmental aspects are to be included, resource efficiency should be included in the Ecodesign Directive and the link to the European Ecolabel should be strengthened, among other things, through streamlining the definitions, requirement levels and the review rate of the requirements. Furthermore, the ‘passing the buck’ strategy should be avoided through a strengthened interplay.

The final conclusion to be drawn from Chapter 3 is that the European Commission is in the process of changing some of the points criticised in the above. Specifically, the change in the focus in the EU deserves to be mentioned, as an on-going change is taking place from energy, towards including resource efficiency in particular. This is visible in a number of projects that have been initiated, but also in the requirements of more recent implementing measures, which include information requirements related to resource efficiency.

## 6.2. A CASE STUDY OF THE IMPLEMENTING MEASURE FOR TELEVISIONS

In Chapter 4, a case study of the implementing measure for televisions was presented, and the conclusions of this chapter strengthen and underline the above conclusions. The television case appeared to be a case of slow requirement development, which led to outdated requirements, and therefore, a low ambition level, especially concerning the requirements for on mode power consumption. In addition, the scope of the implementing measure was narrow by—besides a few information requirements—solely including requirements for energy in the use phase. The requirements for on mode power consumption is based on a linear equation allowing bigger television screens a larger on mode power consumption. This is unfortunate considering the market trend of growing screen sizes. As long as the implementing measure focuses on energy efficiency, and accepts the relation between screen size and power consumption, there is a risk of not achieving absolute energy savings. Due to the fast technological development during the time of requirement development, it was concluded that the influence of the implementing measure is limited to having pushed the technological development.

In addition, an unfulfilled potential was identified in the improvement of the interplay between the implementing measure for televisions, the Energy Label, and the European Ecolabel. It is concluded that if the requirements are co-developed, they could reduce the long time for requirement development, and it possibly implies a better understanding of the technological development, because the time horizon is shorter. Finally, it could improve the synergy between the requirement levels in the implementing measure and the European Ecolabel.

Finally, the political agenda in the EU has shifted towards taking a comprehensive approach to ecodesign. The analysis shows that several important strategy documents and action plans aim at a resource efficient Europe and the Ecodesign Directive is highlighted as one of the instruments that can achieve this progress. However, the focus of the implementing measures and voluntary agreements has to be expanded to cover more life cycle phases and environmental impacts. Furthermore, the equation, which determines the on mode power consumption requirement, is being changed to a logarithmic equation, which does not favour the larger screen sizes and the requirement is tightened. Resource efficiency information requirements are included and the implementing measure is revised in parallel to the Energy Label and the European Ecolabel, which improves the interplay between the instruments. The overall conclusion from Chapter 4 is, therefore, that the ambition level of the currently in force implementing measure is low, but that this is improving with the on-going revision of the implementing measure.

## 6.3. ECODESIGN REQUIREMENTS FOR TELEVISIONS

In the paper *Ecodesign requirements for televisions—is energy consumption in the use phase the only relevant requirement?*, a life cycle assessment of two different televisions is presented with the aim of analysing if other requirements besides energy consumption in the use phase are relevant to include in the implementing measures. The life cycle assessments are conducted using the consequential approach, meaning that constrained suppliers are excluded from the modelling, and allocation is avoided through system expansion. The paper concludes that the two environmental impact categories with the highest contribution are global warming and respiratory inorganics. The lifecycle phase with the highest environmental impact is the production phase, and the use phase is the second largest lifecycle phase. The sensitivity analysis reveals that even though applying a 100% coal based electricity scenario, which implies that the use phase becomes the most important lifecycle phase, the contribution from the production phase is still significant, and in absolute numbers the impact from the production phase has increased 50% compared to the consequential scenario. On this basis it is concluded that energy consumption is an important environmental impact, but that the production phase is also relevant to include in the requirements. The paper further concludes that the more energy efficient the televisions become in the use phase, the more important it is to set up requirements for the production phase as well.

The paper underlines the conclusions from Chapter 4 that the implementing measures are not up to date with the technological development. The two televisions used in the life cycle assessments are chosen in collaboration with the producers, and one selection criteria was that the televisions should be representative of the producers' collection of televisions in terms of sales figures and technology. Both televisions are based on the LED technology, which in the preparatory studies, was assessed to be an immature technology.

## 6.4. REFLECTIONS

A question regarding the research focus of the study is, why the process around developing and adopting the implementing measures and the involvement of stakeholders is not analysed further. An option could have been to interview people from, for example, the research institutions, which complete the preparatory studies or the evaluations of the Ecodesign Directive, the government officers and politicians developing and adopting the implementing measures and the companies, business associations and businesses, and government officials from the EU member states, who provide input to the process. Through such analyses, the specific influences of the different stakeholders could have been clarified and, for example, to what degree the requirements in the implementing measures are a compromise between the different stakeholders. In this way, a clearer picture could have been provided of, for instance, why the technological development happened at such a fast pace—was it coincidence or did the anticipated ecodesign requirements speed up the process? This could have answered the question of whether the ecodesign requirements for televisions, which were be rather unambitious, really were the best estimate of experts or if certain stakeholders influenced the requirement level. However, as the initial analysis of the Ecodesign Directive revealed a low ambition level and little possibility for driving innovation forward, I found it more interesting to move the focus of the study to the companies affected by the Directive and implementing measures and how why they work with ecodesign, which is the topic of Part II of this thesis.

## 6.5. MOVING ON

In summary, the analyses in Part I revealed several difficulties in the implementation of the Ecodesign Directive, and also that most of the points of criticism now are being corrected. However, the value of the Directive and its implementing measures in setting comprehensive ecodesign requirements and the effect of a closer interplay with the European Ecolabel and the Energy Label is still to be demonstrated—just as the Directive and implementing measures' ability to forecast and take into account the technological development. As the analysis of the implementing measures for television illustrate, the ecodesign innovations appear to be driven by the technological development rather than the implementing measures.

All things considered, the analyses in Part 1 piqued a curiosity as to why companies work with ecodesign, and what is actually driving their environmental agenda concerning their products. This is the focus of the second part of this thesis.

# PART II – THE COMPANIES

In this second part of the thesis, focus is directed towards the companies, which are influenced by the Ecodesign Directive. In the first part, the conclusion was that the Ecodesign Directive provides a framework for setting comprehensive ecodesign requirements, but that the implementation of the Ecodesign Directive entails a unilateral focus on energy in the use phase. This is particularly the case in the early adopted implementing measures, whereas the more recent implementing measures and voluntary agreements have set up requirements for other life cycle phases and environmental impact categories. Furthermore, the case study of televisions showed that the ambition level of the minimum requirements has been low and that the eco-innovations in this case seem to be driven by technological development rather than the Ecodesign Directive, even though the Directive might have speeded up the technological change.

Although this is particularly the case for televisions, it piqued my curiosity regarding why companies work with ecodesign in the first place and what role the Ecodesign Directive actually plays. The analysis is conducted through a case study of three Danish companies: Grundfos, B&O and Danfoss PE. In the following, the research questions that guide the analysis in Part II are presented along with the structure of Part II of this thesis.

## RESEARCH QUESTIONS AND STRUCTURE OF PART II

**Chapter 7 Presentation of the Case Companies** gives a background description of the three case companies.

**Chapter 8 Sustainability and Company Strategies** concerns the case companies' sustainability strategies and the integration of them in practice. In this first step of the analysis, the focus is on the company strategies, as these lay the foundation of the goals and activities of the companies. The analysis concentrates on strategies, which include sustainability. Within this delimitation, it is implicitly given that a company's approach to sustainability is an indicator of the company's ecodesign activities. Even if companies do not have a specific strategy targeting ecodesign, companies often have a strategy including sustainability, which might indirectly say something about the company's strategy for ecodesign. The research question that guides the analysis is:

> *How can Grundfos', Bang & Olufsen's and Danfoss Power Electronics' sustainability strategies be characterised?*

**Chapter 9 Drivers and Barriers of Ecodesign** concerns the specific drivers and barriers for working with ecodesign in the case companies, and the focus is on the actual practices of the companies both on a management and an operational level. Specific attention is also directed towards the influence of the Ecodesign Directive on the case companies. The analysis is guided by a model originally describing the drivers and barriers of eco-innovation. It is argued that eco-innovation and ecodesign to a large extent are comparable, and as such, the model can be applied to ecodesign as well. The guiding research question to the analysis is:

> *What are the drivers and barriers of ecodesign in Grundfos, Bang & Olufsen and Danfoss Power Electronics, and what is the influence of the Ecodesign Directive?*

**Chapter 10** includes the paper **Understanding Ecodesign through a Communities of Practice Perspective**. The aim is to take the analysis of the case companies one step further and find solutions to how companies' ecodesign efforts can be improved. The paper focuses on B&O and an anonymous case company. The case companies are anonymous in the paper, due to the wish of the second case company. The paper takes a practice perspective as to how ecodesign can be strengthened through cultivating communities of practice. The research question that guides the analysis is:

> *How can ecodesign practices be strengthened by cultivating communities of practice?*

Finally, in **Chapter 11**, the three research questions are answered, and the chapter constitutes the conclusion to Part II of the thesis.

# CHAPTER 7. PRESENTATION OF THE CASE COMPANIES

In this chapter, the three case companies, Grundfos, B&O and Danfoss PE, are introduced. The aim of the chapter is to present thorough background information on each company, which serves as a foundation for the analyses in the following chapters. As such, no analyses are presented in this chapter, but the topics included are selected on the basis that they together will give the reader an understanding of the companies' capabilities and resources in relation to working with ecodesign and environmental issues in the product development.

The introductions include a brief historical outline and some current facts on, among other things, company size, ownership and product portfolio. Based on the organisational diagrams, the structure of the companies' environmental activities is briefly described. The product development processes are presented, as these are essential for understanding how ecodesign practices are or can be integrated, and an overview is given of the implementing measures of the Ecodesign Directive, which are relevant for the companies.

## 7.1. GRUNDFOS

### 7.1.1. HISTORY

Grundfos was founded in 1944 by Poul Due Jensen in the basement of his private villa, but 1945 is the celebratory year for Grundfos' anniversaries, because this was when the first series production of pumps began. The name Grundfos was not synonymous with the company until 1967. From the beginning, Grundfos has been family owned. In 1975 the majority of shares was given to the newly established Poul Due Jensen Foundation, which is still the owner of Grundfos (Grundfos, n.d.).

In the first year of Grundfos' existence, the focus was primarily on heating and sanitation, but already by 1945, came the idea to develop an electric pump. In the following years, several types of pumps were developed, such as a pump for deep ground water, a multistage centrifugal pump, and in 1959 the first circulator pump, which was applicable in central heating circulation as well as for domestic hot water circulation. Grundfos grew steadily, and the first exports began in 1949. In 1960 the first subsidiary was established in Wahlstedt, Germany (Grundfos, n.d.).

> 'Grundfos runs its business in a responsible and ever more sustainable way. We make products and solutions that help our customers save natural resources and reduce climate impact. We take an active role in the society

> around us. Grundfos is a socially responsible company. We take care of our people—also those with special needs.' (Grundfos, 2014, p.1)

This business focus of taking responsibility for the surrounding communities had already begun in the early years, at first focusing primarily on social issues. In 1968, Grundfos was the first privately owned company in Denmark to open a sheltered workshop for employees with special needs. Later, attention was also directed particularly towards energy efficiency and sustainability as an overall concept. Grundfos received its first ISO 14001 certification in 1996, and today all production sites are ISO 14001 certified and the European sites also have an EMAS registration. In 2002, Grundfos joined the UN Global Compact (United Nations Global Compact, n.d.). In 2008, the Innovation Intent, which is presented in detail in section 8.6.1, was introduced with a focus on the long-term innovation efforts, and with sustainability high on the agenda at Grundfos (Grundfos, n.d.).

As regards the focus on energy efficiency, high pump efficiency has, from the beginning, been in focus, but the development of a frequency converter controllable by a microprocessor in 1980 provided entirely new opportunities. The continuous development resulted in the launch of the first 'intelligent' pump in 1991, which resulted in large energy savings, and it was subsequently incorporated in many of Grundfos' pumps. The first low-energy efficiency pump, the Alpha PRO, was introduced in 2005. The pump's pressure and flow was constantly adjusted due to automatic control, and it automatically adjusted itself to day or night and to summer or winter. The permanent motor technology had been applied to the first pump in Grundfos in 1998, but it was in 2010 that this technology became popular. This technology allows for energy savings up to 70% compared to pumps of similar size, and it is the foundation for the energy efficiency achievements of the newest Grundfos pumps (Grundfos, n.d.; Director, Grundfos, 2015).

### 7.1.2. GRUNDFOS TODAY

Today, Grundfos is a world-wide company with more than 80 companies in more than 55 countries. Grundfos is the largest producer of circulators, and covers around 50% of the world market. Sixteen million pumps are produced every year, including circulators for heating and air conditioning, and centrifugal pumps for industry, heat supply, water supply, sewage water and dosage (Grundfos, 2014).

Grundfos is still 87.8% owned by the Poul Due Jensen Foundation. The employees own 1.6% and the family of the founder owns the remaining 10.6% (Grundfos, 2014). The key figures for 2012 are presented in Table 7 and the organisational structure is illustrated in Figure 20.

*Table 7: Grundfos' key figures for 2012 (Grundfos, 2014).*

| | |
|---|---|
| Turnover | 22,590 million DKK |
| Number of employees | 17,984 |

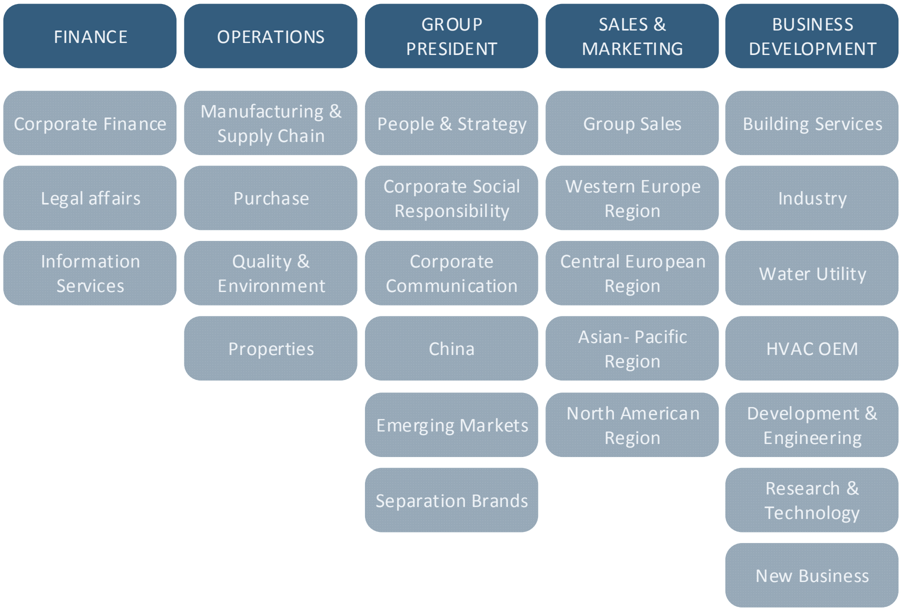


*Figure 20: Grundfos' organisational structure (Grundfos, 2011).*

### 7.1.3. STRUCTURE OF THE ENVIRONMENTAL WORK

Grundfos has organised its environmental activities in two overall departments. The main responsibilities of Quality & Environment under Operations in relation to environmental issues are to reduce the environmental impact from the Grundfos Group in general, related to both the impact of the production sites, the product and the entire product chain, and secondly, to improve the working environment (environment engineer, Grundfos, 2012). The Group Corporate Social Responsibility, which in 2012 changed its name to Group Sustainability, is Grundfos' overall umbrella for the stakeholders regarding all aspects of sustainability, e.g. development and implementation of the code of conduct and the sustainability strategy (sustainability consultant, Grundfos, 2012).

### 7.1.4. RESTRUCTURING OF RESEARCH AND DEVELOPMENT

When the interviews for this study were conducted, Grundfos had been restructuring the Research & Development (R&D) organisation, in order to meet future challenges and improve Grundfos' ability to supply. Traditionally, the R&D department consisted of the Development and Engineering Department, where product development projects were managed, and the Research and Technology Department, where new technologies were developed. The restructured organisation is illustrated in Figure 21. The overall project manager is the global programme development manager (GPDM), who is able to lead several projects at the same time. For each project, three project managers report to the GPDM, each responsible for his or her own area. These are New Business Implementation (NBI), the New Development Implementation (NDI) and the New Production Implementation (NPI). The NBI and the NPI organisationally belong to Sales and Marketing and Operations, respectively, but are brought into to the process by the GPDM. The NDI can utilise the products from three different flow streams: Electronic Systems, Electro Mechanical Systems and Mechanical Hydraulic Systems. Technological development is done in a separate department and is only included in the product development when the technologies are ready. Furthermore, Grundfos bases its product development on platform technologies, called frontloading, in Figure 21 (product development manager, Grundfos, 2013).

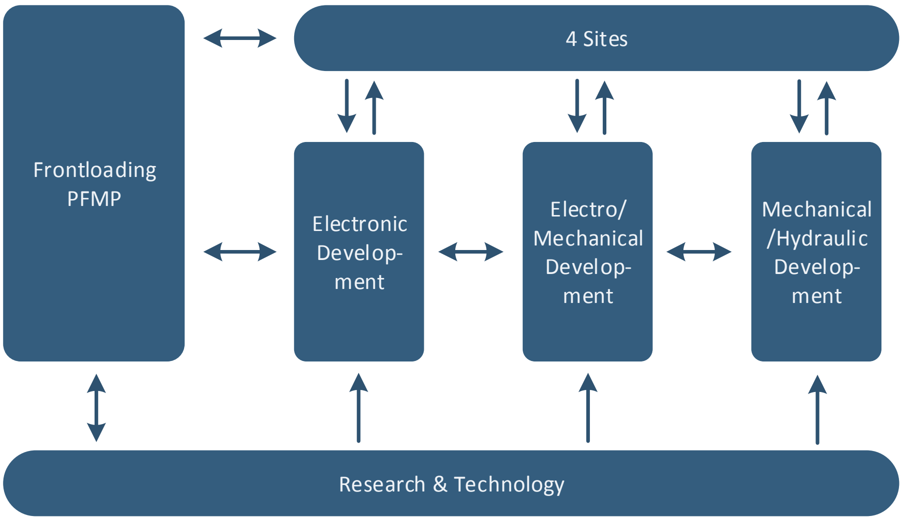


*Figure 21: The project management (product development manager, Grundfos, 2013).*

In addition to the restructuring of project management, a new support function is established within the Development and Engineering Department (D&E). The aim is to gather different support areas for product development, which previously was more spread out through the organisation (product development manager, Grundfos, 2013). Global Support is divided into three areas: Continuous Improvement & Strategy; Quality, Processes & Tools; and Approvals. In Continuous Improvement and Strategy, a change agent within sustainable product solutions is hired. The change agent is first hired to be responsible for sustainability directly in product development, but the change agent is in connection with restructuring of the R&D organisation moved to the Continuous Improvement and Strategy Department (change agent, Grundfos, 2013).

### 7.1.5. GRUNDFOS' STRATEGY AND POLICY DOCUMENTS RELATED TO SUSTAINABILITY

Grundfos' focus on sustainability has resulted in a number of mission statements, policy and strategy documents (see Table 8). These are analysed more in detail in Chapter 8 and 9, but in the following, an overview of the documents is presented. Besides the publicly available strategies, sustainability issues are included in some of the departments' own strategies, for instance in D&E.

*Table 8: Publicly available mission statements, visions and strategy documents related to sustainability.*

| **Name of document** | **Purpose** |
|---|---|
| Grundfos Purpose | The Vision and Mission of Grundfos |
| Be – Think – Innovate | Expresses Grundfos' purpose and promise to contribute to global sustainability |
| The Grundfos Values | The foundation for Grundfos' business conduct |
| Innovation Intent | Grundfos' guide for business conduct on a long-term and short-term basis |
| Shared Value Model | Used to identify and prioritise Grundfos' initiatives to ensure value creation along the entire value chain |
| Climate White Paper | The framework for how Grundfos tackles the climate challenge |
| Sustainability Strategy | Compilation and prioritisation of Grundfos' sustainability efforts |

### 7.1.6. THE PRODUCT DEVELOPMENT PROCESS

Grundfos' product development process is a classic stage-gate model (see Figure 22). It consists of seven stages. At the end of each stage, the status is evaluated, and this is called a decision point (DP).

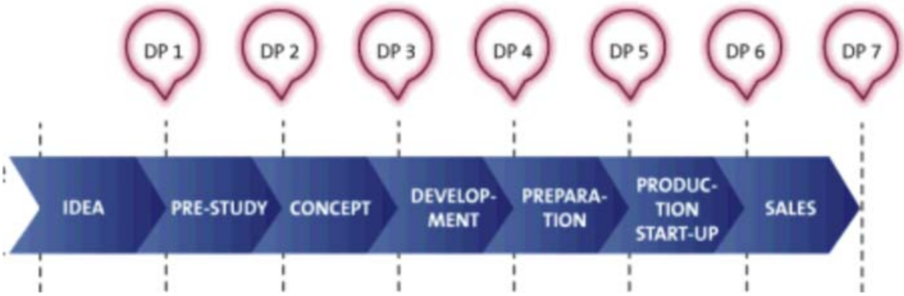


*Figure 22: Grundfos' product development process (Grundfos Insite, 2012).*

In the idea stage, a two-page document with the idea behind the product is developed by the GPDM, who gathers input from different stakeholders in Grundfos (senior project manager, Grundfos, 2012; global programme manager, Grundfos, 2012). The idea is accepted at DP1, and thereafter, the product concept specification (PCS) is developed. This is the document containing all relevant requirements for the product, and it is approved at DP2. In the concept stage, the product development team specifies the product further, e.g. in terms of what the product will cost to produce, which production facilities to use and at what price the product is to be sold. At this stage, the PCS is further specified into a product requirement specification (PRS), which is more detailed and useful for the product developers. After DP3 the actual development of the product begins. At DP4 the construction of the product is final and the preparation for the production begins. After DP5 the actual production takes place and at DP6 the product is ready to release for sale (senior project manager, Grundfos, 2012).

### 7.1.7. GRUNDFOS AND THE ECODESIGN DIRECTIVE

Grundfos is covered by two adopted implementing measures of the Ecodesign Directive. They are:

- Commission Regulation (EC) No. 640/2009 of 22 July 2009—electric motors
- Commission Regulation (EC) No. 641/2009 of 22 July 2009—glandless standalone circulators and glandless circulators integrated in products

In addition, the European Commission is working on two implementing 57measures regarding large water pumps and waste water pumps relevant for Grundfos. As they are under development by the European Commission, they are not included in this study. Below, the requirements of the implementing measures for electric motors and circulators are briefly presented.

**Commission Regulation (EC) No. 640/2009—electric motors**

The implementing measures for electric motors went into force on 12 August 2009. An amendment to the regulation went into force on 27 January 2014, which clarifies the exceptions to the scope in article 1, in order to avoid loopholes in the application.

The regulation defines a motor efficiency classification with IE2 being the low and IE3 being the high motor efficiency. The main ecodesign requirements of the regulation are listed in Table 9. (The requirements are slightly simplified to ease the reading.)

*Table 9: The main ecodesign requirements for electric motors (European Commission, 2009).*

| | |
|---|---|
| From 16 June 2011 | Motors shall not be less efficient than the IE2 efficiency level |
| From 1 January 2015 | Motors with a rated output of 7.5–375 kW shall not be less efficient than the EI3 efficiency level, or meet the IE2 efficiency level and be equipped with a variable speed drive. |
| From 1 January 2017 | All motors with a rated output of 0.75–375 kW shall not be less efficient than the IE3 efficiency level, or meet the IE2 efficiency level and be equipped with a variable speed drive. |
| From 16 June 2011 | Information requirements |

The estimated annual savings in 2020 as a result of this regulation are 135 TWh (European Commission Enterprise & Industry, 2013).

**Commission Regulation (EC) No. 641/2009—circulators**

The implementing measures for circulators went into force on 12 August 2009. It defines an energy efficiency index and sets minimum requirements. The main ecodesign requirements are listed in Table 10. (The requirements are slightly simplified to ease the reading.)

*Table 10: The main ecodesign requirements for circulators (European Commission, 2009b).*

| | |
|---|---|
| From 1 January 2013 | Glandless standalone circulators, with the exception of those specifically designed for primary circuits of thermal solar systems and of heat pumps, shall have an energy efficiency index (EEI) of not more than 0.27 |
| From 1 August 2015 | Glandless standalone circulators and glandless circulators integrated in products shall have an energy efficiency index (EEI) of not more than 0.23 |
| From 1 January 2013 | Information requirements |

The estimated annual savings in 2020 as a result of this regulation are 23 TWh (European Commission Enterprise & Industry, 2013).

## 7.2. BANG & OLUFSEN

### 7.2.1. HISTORY

B&O was founded in 1925 by two young engineers, Peter Bang and Svend Olufsen, who met during their studies and shared the enthusiasm for the new phenomenon—the radio. The first product was the ‘eliminator’, which was a main receiver that eliminated the need for batteries. The sales from the ‘eliminator’ ensured enough capital to build a factory. Since the first product, B&O has focused on the production of audio products, such as radio and loudspeakers. Later telephones, music systems, televisions and sound systems for cars were added to the product portfolio, but it was not until the 1960s that B&O found its niche in focusing on product design and quality, and began to collaborate with architects and designers on the product design (Bang & Palshøj, 2000).

It was also in the 1960s that B&O started to sell its products abroad (Bang & Palshøj, 2000). B&O obtained a stock exchange quotation in 1977, which remains today (Bang, n.d.).

For B&O, environmental concerns are an imbedded aspect of producing quality products, but it is not an aspect used to brand the company (senior director Idea Factory, B&O, 2012). One particular technology developed in a joint venture with the Technical University of Denmark deserves to be mentioned. The ICEpower technology is a digital amplifier technology that not only reduces the energy consumption by a factor ten compared to conventional technologies, it also reduces the material consumption because of the significantly reduced size of the amplifier (B&O, n.d.). B&O's Danish activities achieved the ISO 14001 and OHSAS 18001 certifications in 2010 (B&O, 2012).

### 7.2.2. BANG & OLUFSEN TODAY

Today, B&O describes its brand as 'an icon of performance and design excellence through its long-standing craftsmanship tradition and the strongest possible commitment to high-tech research and development' (B&O, 2012b, p.3). B&O has two lines of business, illustrated in Figure 23, and the products are sold in more than 70 countries worldwide. The business-to-consumer (B2C) line covers the AV business, which includes the traditional audio and video products, and B&O PLAY, which includes the newest brand by B&O and offers quality products for the younger generation. The business-to-business (B2B) line covers the automotive business, which is sound systems for cars, and the ICEpower technology, which was mentioned in the section above (B&O, 2012b). However, in March 2015, B&O entered into an automotive brand licence agreement and thereby transferred its automotive assets to another company (B&O, 2015).


*Figure 23: B&O's two lines of business (B&O, 2012b).*

The key figures for the financial year 2011/2012 are presented in Table 11, and the organisational structure is illustrated in Figure 24.

*Table 11: B&O's key figures for the financial year 2011/2012 (B&O, 2012b).*

| | |
|---|---|
| Turnover | 3,008 million DKK |
| Number of employees | 2,032 |

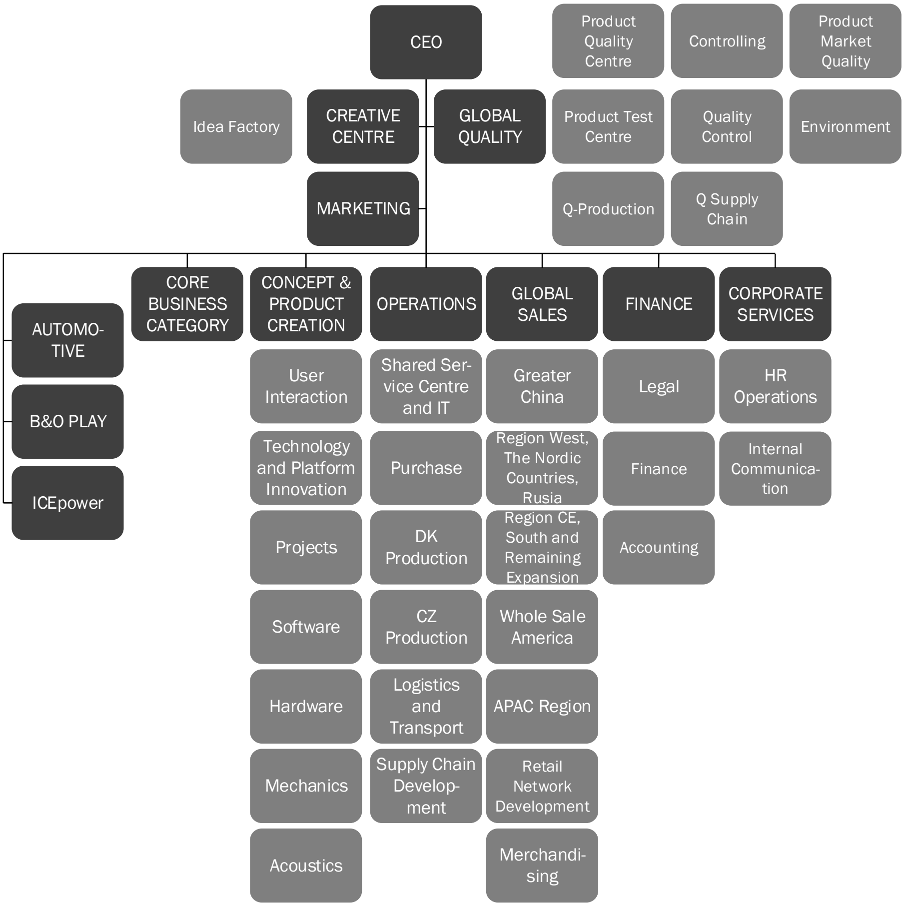


*Figure 24: B&O's organisational structure (environmental consultant, B&O, 2012; environmental consultant, B&O, 2013).*

### 7.2.3. STRUCTURE OF THE ENVIRONMENTAL WORK

Since 2011 B&O does not have a separate environmental department (environmental consultant, B&O, 2012). Instead, the responsibilities are scattered throughout different departments. Product related environmental issues are handled by the environmental consultant in the Product Quality Centre, environmental issues related to the production and working environment are handled by an environmental coordinator and an environmental manager in the Quality Department, and work related to the supplier assessment is managed by the Purchasing Department.

### 7.2.4. BANG & OLUFSEN'S STRATEGY AND POLICY DOCUMENTS RELATED TO SUSTAINABILITY

B&O has two main documents outlining B&O's conduct in relation to sustainability (see Table 12). These are analysed more in detail in Chapters 8 and 9.

*Table 12: Publicly available policy and strategy documents related to sustainability.*

| Name of document | Purpose |
|---|---|
| CSR policy | Formalises and clarifies B&O's approach to CSR |
| CSR strategy (in progress/not yet available) | Defines B&O's work with CSR further and defines specific focus areas |

### 7.2.5. THE PRODUCT DEVELOPMENT PROCESS

B&O's product development process in itself is a classic stage-gate model and it is supported by a FRAMING and EXPLORATION process (see Figure 25). Before the actual product development process, named BUSINESS in the model, a strategic process (SCOPE) takes place, where how the product portfolio of B&O should look like in the coming years is decided, based on, among other things, the corporate strategy (senior manager Product Quality Centre, 2014).

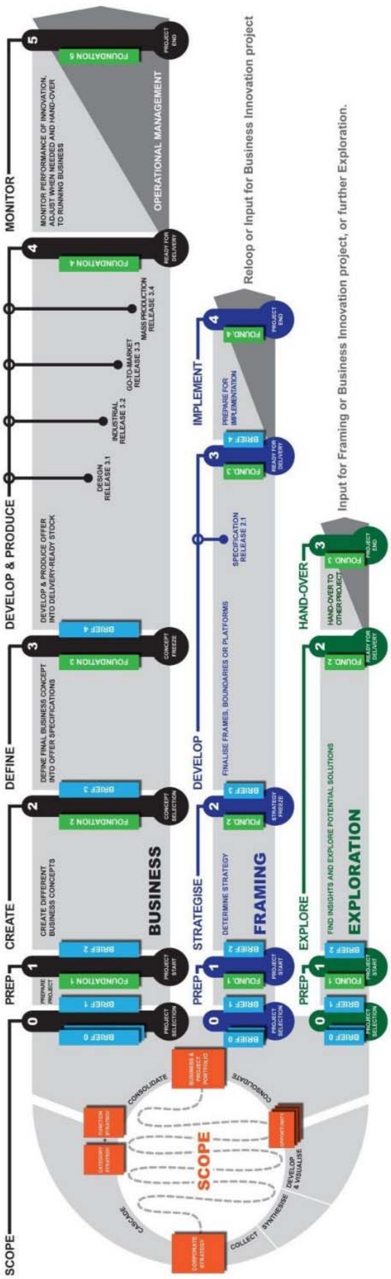


*Figure 25: B&O's product development process (senior manager Product Quality Centre, 2014b).*

The product development process consists of five stages, and the product requirement specifications are fixed at stage three, and subsequently, the actual development of the product begins. The FRAMING process concerns development of platform technologies that are used in the different product development projects. The platform technologies developed depend on the product portfolio decided in the SCOPE process. The EXPLORATION process takes place earlier than the FRAMING process and explores what types of platform technologies are necessary to follow the product portfolio decided in the SCOPE process. The three processes can to some extent run in parallel, but in general the EXPLORATION process takes place first, followed by the FRAMING, and finally the actual product development process takes place (senior manager Product Quality Centre, 2014).

### 7.2.6. BANG & OLUFSEN AND THE ECODESIGN DIRECTIVE

B&O is covered by four adopted implementing measures of the Ecodesign Directive. They are:

- Commission Regulation (EC) No. 1275/2008 of 17 December 2008—standby and off mode
- Commission Regulation (EC) No. 642/2009 of 22 July 2009—televisions
- Commission Regulation (EC) No. 278/2009 of 6 April 2009—battery chargers and external power supplies
- Commission Regulation (EU) No. 801/2013 of 22 August 2013—networked standby

Below, the requirements of the implementing measures for the above are presented in brief.

**Commission Regulation (EC) No. 1275/2008—standby and off mode**

The regulation for standby and off mode went into force on 7 January 2009, and it sets standby consumption and off mode requirements for small and large household appliances. The requirements are horizontal, meaning that they apply to all products in scope of the Ecodesign Directive, even though the specific requirements for the product groups are not adopted. The main ecodesign requirements of the regulation are listed in Table 13. (The requirements are slightly simplified to ease the reading.)

*Table 13: The main ecodesign requirements for standby and off mode (European Commission, 2008).*

| | |
|---|---|
| From 7 January 2010 | Power consumption of equipment in any off mode condition shall not exceed 1.00 W |
| From 7 January 2010 | The power consumption in standby shall not exceed 1.00 W |
| From 7 January 2010 | The power consumption in standby with information or status display shall not exceed 2.00 W |
| From 7 January 2010 | Equipment shall provide off mode and/or standby mode when the equipment is connected to the main power source |
| From 7 January 2013 | Power consumption of equipment in any off mode condition shall not exceed 0.50 W |
| From 7 January 2013 | The power consumption in standby shall not exceed 0.50 W |
| From 7 January 2013 | The power consumption in standby with information or status display shall not exceed 1.00 W |
| From 7 January 2013 | Equipment shall provide off mode and/or standby mode when the equipment is connected to the mains power source |
| From 7 January 2013 | When equipment does not provide the main function, or when other energy-using product(s) are not dependent on its functions, equipment shall offer a power management function |
| From 7 January 2010 | Information requirements |

The estimated annual savings in 2020 as a result of this regulation are 35 TWh (European Commission Enterprise & Industry, 2013).

**Commission Regulation (EC) No. 642/2009—televisions**

The regulation for standby and off mode went into force on 12 July 2009, and it sets requirements to the on mode, standby and off mode power consumption of televisions. Additionally, there are requirements to a home-mode, peak luminance ratio and information requirements. Because these requirements are analysed in detail in Part I of this thesis, they are not explained further here.

The estimated annual savings in 2020 as a result of this regulation are 28 TWh (European Commission Enterprise & Industry, 2013).

Currently, the Commission is working on draft setting requirements for electronic displays, repealing the Commission Regulation (EC) No. 642/2009 of 22 July 2009—televisions. The draft, among other things, broadens the scope of the regulation to include other display product groups such as computer displays and digital photo frames. Furthermore, it sets resource efficiency and end of life requirements (European Commission, 2015). As these requirements are analysed in Part I of this thesis, they are not explained further here.

**Commission Regulation (EC) No. 278/2009—battery chargers and external power supplies**

The regulation went into force 27 April 2009, and it set requirements to the no-load power consumption and the average active efficiency. The main ecodesign requirements of the regulation are listed in Table 14. (The requirements are slightly simplified to ease the reading.)

*Table 14: The main ecodesign requirements for battery chargers and external power supplies (European Commission, 2009c).*

| | |
|---|---|
| From 27 April 2010 | The no-load condition power consumption shall not exceed 0.50 W |
| From 27 April 2010 | The average active efficiency shall be no less than:<br><br>$0.500 \cdot PO$, for $PO < 1.0$ W;<br>$0.090 \cdot \ln(PO) + 0.500$, for $1.0\text{ W} \leq PO \leq 51.0$ W;<br>$0.850$ for $PO > 51.0$ W |
| From 27 April 2011 | The no-load condition power consumption shall not exceed the following limits: 0.5 W or 0.3 W, depending on type |
| From 27 April 2011 | Tightening of the average active efficiency requirements |
| From 27 April 2010 | Information requirements |

The estimated annual savings in 2020 as a result of this regulation are 9 TWh (European Commission Enterprise & Industry, 2013).

### Commission Regulation (EU) No. 801/2013—networked standby

The regulation went into force in September 2013, and it is an amendment to Commission Regulation (EC) No. 1275/2008 on standby and off mode. The amendment includes networked standby power consumption requirements, and specific requirements regarding televisions and coffee machines. The main ecodesign requirements of the regulation are listed in Table 15. (The requirements are slightly simplified to ease the reading.)

*Table 15: The main ecodesign requirements for networked standby (European Commission, 2013).*

| | |
|---|---|
| From 1 January 2015 | Any networked equipment that can be connected to a wireless network shall offer the user the possibility to deactivate the wireless network connection(s) |
| From 1 January 2015 | The power consumption of HiNA equipment or equipment with HiNA functionality in a condition providing networked standby into which the equipment is switched by the power management function, or a similar function shall not exceed 12.00 W |
| From 1 January 2015 | The power consumption of other networked equipment in a condition providing networked standby into which the equipment is switched by the power management function, or a similar function, shall not exceed 6.00 W |
| From 1 January 2017 | The power consumption of HiNA equipment or equipment with HiNA functionality, in a condition providing networked standby into which the equipment is switched by the power management function, or a similar function, shall not exceed 8.00 W |
| From 1 January 2017 | The power consumption of other networked equipment in a condition providing networked standby into which the equipment is switched by the power management function, or a similar function, shall not exceed 3.00 W |
| From 1 January 2019 (televisions) | The power consumption of televisions without HiNA functionality in a condition of networked standby into which the television is switched by the power management function, or a similar function, shall not exceed 2.00 W |

The estimated annual savings in 2020 have not been calculated for this regulation.

## 7.3. DANFOSS POWER ELECTRONICS

### 7.3.1. HISTORY

In 1933 Mads Clausen established Dansk Køleautomatik og Apparat Fabrik (in English: Danish Refrigeration Controls and Apparatus Manufacturer) on his parents' farm. In 1946, the company changes its name to Danfoss. Danfoss grew steadily, and the first contract with a dealer abroad was made in 1939, and in 1958 the first factory outside Denmark was a reality in Flensburg, Germany. In 1971, the Dorthea Clausens Foundation (later Bitten and Mads Clausen's Foundation) was established and handed over the majority of the A-shares. By that time Danfoss reached 7,000 employees and the business was divided into three main, large groups; the Automatic Controls Group (Refrigeration, Heating, Industrial), the Oil Group (Hydraulics and Burner Components), and the Compressor Group (Compressors and Evaporator Thermostats). In addition, there was a Central Group (Central Manufacturing and Service), the Sales Group and a number of smaller functions (Danfoss, n.d.).

Danfoss' business has, from the very beginning, focused on producing valves and compressors, and in 1943 the first thermostatic valves were produced. At first the technologies developed were mechanical, but during the Second World War the electro-mechanical components were introduced with the motor protecting switch and starting relay. The breakthrough for electronics was the VLT frequency converter in 1968, and later also microelectronics were part of Danfoss' portfolio (Danfoss, n.d.).

Danfoss was aware, early on, of its responsibility towards society, and in the early years it focused primarily on the social side of sustainability. In 1956 a Welfare and Interest Office was established to administer the many support schemes and foundations, which had been established. Regarding environmental awareness, since before the first Danish environmental regulation in 1973, Danfoss has strived to be proactive and in front of environmental regulation. The first factory received its environmental certificate according to the British Environmental Standards, BS7750, in 1995. Later, it was replaced by ISO 14001. Danfoss signed the International Chamber of Commerce's Charter on Sustainable Development and in 2002 Danfoss joined the UN Global Compact (Danfoss, n.d.).

### 7.3.2. DANFOSS POWER ELECTRONICS TODAY

Today, Danfoss has 58 sales companies in 46 countries, and 59 factories in 18 countries (Danfoss, n.d., b). The product portfolio includes solutions within refrigeration and air conditioning, heating, VLT drives, solar energy, power, silicon power modules, industrial automation and high pressure pumps (Danfoss n.d., c).

Danfoss' share capital is divided into two classes; A-shares and B-shares. The A-shares are owned completely by the Bitten and Mads Clausen Foundation and the Clausen family, and in addition they own B-shares corresponding to 98.75% of the votes.

The key figures for 2012 are presented in Table 16; the organisational structure of Danfoss is illustrated in Figure 26, and of Danfoss PE in Figure 27.

*Table 16: Danfoss' key figures for 2012 (Danfoss n.d., b; Danfoss, 2013).*

| | |
|---|---|
| Turnover | 7,906 million DKK |
| Number of employees | 22.500 |

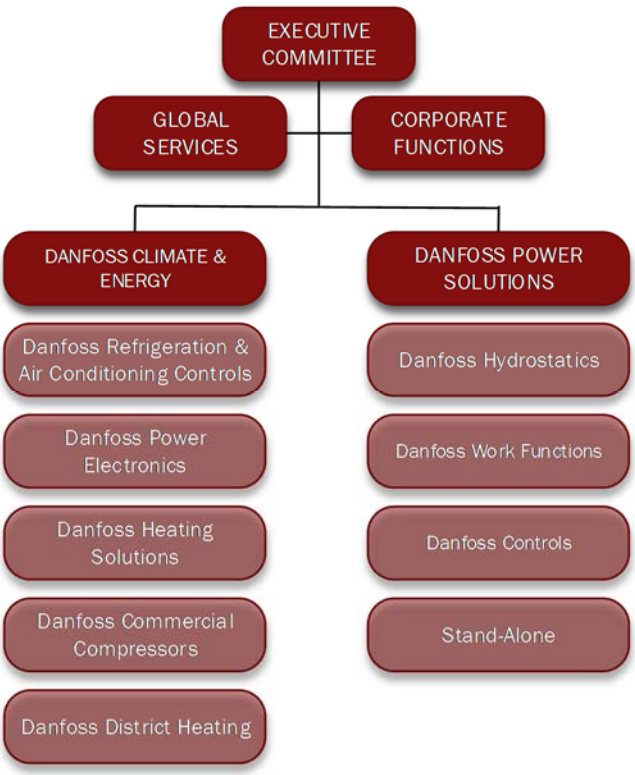


*Figure 26: Danfoss' organisational structure (Danfoss, 2013).*

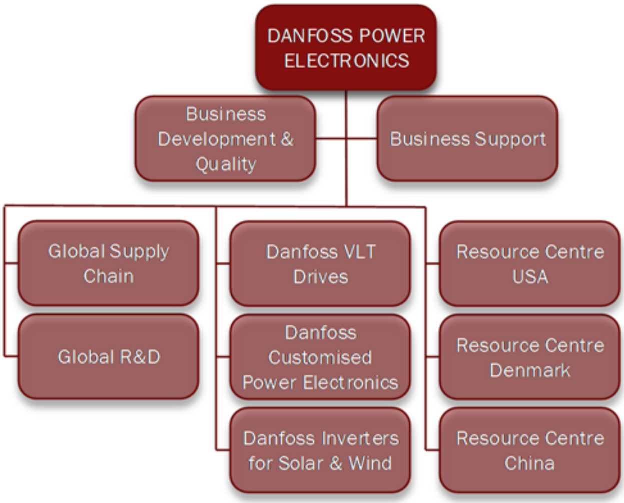


*Figure 27: Danfoss PE's organisational structure (Danfoss, 2012).*

### 7.3.3. STRUCTURE OF THE ENVIRONMENTAL WORK

Following the organisational structure in Danfoss, the environmental-related responsibilities are also divided into corporate function and a quality department in each division. The overall strategic direction of Danfoss' environmental work is set by the corporate function, including setting up policies and implementing different projects on a group level. The division levels, including the Danfoss PE Quality Department, are responsible for, among other things, internal and external environmental issues for each division, such as work environment and the environmental management system. Product related environmental issues are not, however, part of the responsibilities the Danfoss PE Quality Department (environmental coordinator, Danfoss PE, 2012; head of PE Global Quality, Danfoss PE, 2012; corporate environmental manager, Danfoss, 2012).

### 7.3.4. DANFOSS' STRATEGY AND POLICY DOCUMENTS RELATED TO SUSTAINABILITY

Danfoss has three main documents outlining Danfoss' conduct in relation to sustainability (see Table 17). These are analysed more in detail in Chapters 8 and 9, but in the following, an overview of the documents is presented.

*Table 17: Policy and strategy documents related to sustainability.*

| Name of document | Purpose |
|---|---|
| Corporate Policy Environment (internal) | Defines Danfoss' responsibility within environmental issues |
| Sustainability Strategy (launched 2013) | Lays out Danfoss plan to ensure results within prioritised areas, such as product life cycle and ethical behaviour |
| Climate Strategy | Defines Danfoss' aim to reduce $CO_2$ emissions |

### 7.3.5. THE PRODUCT DEVELOPMENT PROCESS

Danfoss PE's product development process is a classic stage-gate model (see Figure 28). It consists of six stages and milestones (M).

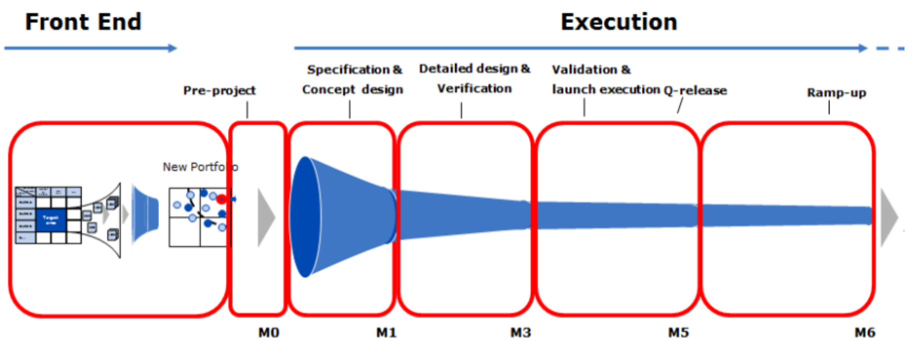


*Figure 28: Danfoss' product development process (project manager, Danfoss PE, 2012b).*

The first stage is the front-end process, where the idea from the segment is developed, and it is decided which project to move forward with. At the pre-project stage, a project manager is assigned to the project and the core team is formed. Between M0 and M1, the concept specification (PCS) is written, and when the project reaches M3, the design of the product is finished including the bill of materials, prices and costs. Between M3 and M5 the project's focus moves to production, and pilot series are produced, tested and verified. At M5 the product is released for production, and until M6, the project focuses on call-rates to ensure a stabile production and product (project manager, Danfoss PE, 2012).

### 7.3.6. DANFOSS POWER ELECTRONICS AND THE ECODESIGN DIRECTIVE

Danfoss PE is indirectly covered by the Commission Regulation (EC) No. 640/2009 of 22 July 2009 on electric motors, which was presented in section 7.1.7. The requirements are applicable for electric motors, but one option for compliance is to equip the motors with a variable speed drive, and hence, Danfoss PE is indirectly covered. Danfoss PE is also directly covered by Commission Regulation (EU) No. 1253/2014 of 7 July 2014 on ventilation units, coming into force December 2014. Further LOTs are in the preparatory stages, which will influence Danfoss PE indirectly. These are: LOT 12 on commercial refrigeration, LOT 21 on heat pumps, LOT 28 on pumps for private and public waste water, etc., LOT 29 on private and public swimming pools and LOT 31 on products outside the scope of LOT 30 and 11. These are not presented further here (Danfoss, 2012b).

Danfoss PE is covered directly by LOT 11 and LOT 30. No ecodesign requirements are adopted yet, but the scope of the LOTs is described in brief, below.

**LOT 11—drives and power drives systems**

LOT 11 covers the product groups, among others: electric motors, circulators, fans and water pumps. Besides the regulation on electric motors, as mentioned, LOT 11 entails a mandate to create a harmonised standard including an energy efficiency classification system for drives, and for power drives systems (PDS), which is a motor and variable speed drive (see Figure 29).

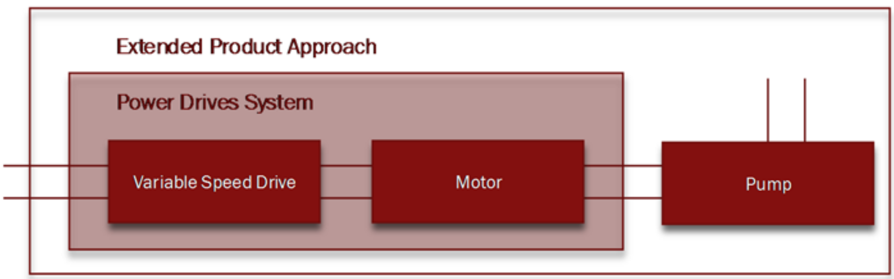


*Figure 29: Power drives system (head of Industry Affairs, Danfoss PE, 2012).*

The initiative to define an efficiency classification system for power drives systems is part of the extended product approach, which focuses on what provides the best efficiency on a system level rather than merely focusing on the individual products (see Figure 29).

According to senior R&D Standardisation at Danfoss PE, the expected outcome of the mandate is a classification for drives with three levels: IE1 (lowest efficiency), IE2 (reference) and IE3 (highest efficiency). Furthermore, it is expected that a second version of the classification will include levels with higher efficiency, e.g. IE4 and perhaps IE5 (senior R&D Standardisation, Danfoss PE, 2012). The standard EN50598 was finished in December 2014, after the research for this PhD study was finalised. The standard and the classification of drives are voluntary, but according to the head of Industry Affairs Danfoss PE (2015) the major manufactures will apply the standard to their products. The classification in three IE classes turned out to be IE0, IE1 (reference) and IE2.

**LOT 30—electric motors**

LOT 30 covers electric motors, which are not in scope in Commission Regulation (EC) No. 640/2009 of 22 July 2009 on electric motors. This covers both motors and drives—for instance, special purpose inverter duty motors, permanent magnet motors and drives such as soft starters. The Preparatory study of this LOT is currently on-going, and the eighth and final task of the study should have been prepared in June 2014 (ISR University of Coimbra & Atkins, n.d.).

### 7.3.7. ADDENDUM

Since the research at Danfoss PE was completed, Danfoss merged with their Finnish competitor on drives, Vacon. Danfoss is now in the second position on the global market for drives. The merger implied a restructuring of the organisation and the new name for the combination of Danfoss PE and Vacon is Danfoss Drives. With the new position as the second largest on the market followed the realisation that Danfoss Drives should take a leadership role in the business concerning issues, such as influencing policy-making in the EU, and standardisation in relation to improving the requirements to energy efficiency in society. The overall agenda in Danfoss as a whole has also shifted, so energy and the climate are the focal points for all Danfoss activities. As a result, Danfoss has established a new corporate unit, named Sustainability, which is responsible for coordinating activities across the entire organisation and ensuring a more uniform approach to, for example, environmental product declarations (EPD). Another outcome is that Danfoss established public affairs offices in Berlin and Brussels (head of Industry Affairs, Danfoss PE, 2015).

Following this introduction of the three case companies, the following chapter takes a closer look at the companies' sustainability strategies.

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# CHAPTER 8. SUSTAINABILITY AND COMPANY STRATEGIES

This chapter focuses on the strategies, which the case companies have applied in their work with sustainability, and the chapter serves as the first step of the analysis of the case companies in this PhD thesis. Discussing the strategies is the first step of the analysis, as the company strategies are the foundation of the companies' goals and activities. Attention is specifically directed towards strategies, which are determining for the company's approach to sustainability. Within this delimitation it is assumed that a company's approach to sustainability is an indicator of the company's ecodesign activities. The research question is: *How can Grundfos', Bang & Olufsen's and Danfoss Power Electronics' sustainability strategies be characterised?*

Numerous definitions of the term 'strategy' exist, but within business strategy a definition often referred to is from Chandler (1966, p.16) who defines strategy as 'the determination of the basic long-term goals and objectives of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals'. This definition is often emphasised as it includes three important elements; namely, that a strategy contains (1) basic long-term goals, and thereby, is setting the direction in which the company should move. A strategy should furthermore include (2) courses of action and (3) allocation of resources, which are both necessary for achieving the goals. A strategy is therefore reflected in both the company documents, particularly the strategic documents, in the actions and activities and in the organisational setup and budgets.

Mintzberg (Campbell, Stonehouse & Houston, 2004) differentiates between deliberate strategies and emergent strategies. Deliberate strategies are planned and meant to happen, and they are generally monitored and controlled from start to finish. Emergent strategies have no specific objective, and are a result of a consistent pattern of behaviour. The emergent can be just as effective as strategies planned in every detail (Campbell, Stonehouse & Houston 2004). For the purpose of this thesis, this distinction is central to the analysis of the company strategies. On the one hand, the analysis includes the deliberate strategies, which are mainly analysed through document analysis, whereas the emergent strategies are analysed through interviews with key persons in the organisation. The aim of this two-sided approach is to achieve a comprehensive understanding of both the written intentions as well as how they are implemented in practice. In Chapter 9, the analysis is taken one step further in analysing the actual actions of the companies.

In order to characterise the sustainability strategies of Grundfos, B&O and Danfoss PE it is useful to develop a conceptual framework as a guiding point when making the interview guides, and as a search tool in the analysis of both documents and interviews. Four existing frameworks are applied as inspiration for the framework developed in this thesis, and they are discussed below. Although three of the four frameworks are especially quite similar, varying primarily on the number of stages of working with sustainability and on a few parameters, they do represent different perspectives for discussing companies' work with sustainability or closely related issues, i.e. corporate social responsibility (CSR) and corporate citizenship, primarily from a strategic perspective. The differences or similarities between the concepts sustainability, CSR and corporate citizenship are not discussed further here, but the three concepts are alike, and are equally useful for analysing a company's sustainability strategies and activities. The LCM Capability Model is included as it focuses on decision processes, which are also considered valuable in strategic processes. The first two frameworks are:

- Corporate social responsibility as shared value
- 3-Stage framework for innovating for business sustainability

The above two frameworks are conceptual frameworks, which are useful when explaining the different approaches a company can take in working with sustainability. Furthermore, these frameworks are useful for understanding the companies' role in society and the extent of their responsibilities in working with sustainability. In addition, the frameworks emphasise sustainability as a value creating opportunity for companies. Even though the frameworks have similar characteristics, they are different in their origin, and therefore, both are included. CSR as a Shared Value framework is developed by Porter and Kramer (2006), and originate from the business science field, and have a point of departure in company strategies. The framework underlines the importance of linking CSR to business strategies and a company's core capabilities, instead of thinking of CSR in generic ways. The development of the 3-Stage framework for innovating for business sustainability is initiated by the Network for Business Sustainability, which is a network for business professionals and researchers. Its focus in developing the framework is not only business strategies but also the actual activities of the companies, leading towards sustainable development. The value of this framework is its succinct description of the three stages in a company's journey towards sustainability.

The third framework presented represents a theoretical and analytical approach useful for analysing the level of engagement in sustainability issues by the company. The framework can be considered a combination between a conceptual framework aiming at understanding and explaining a company's sustainability strategy and an operational framework that provides specific guidance as to which steps a company can pursue in its sustainability efforts. This framework is included due to its level of detail, which allows for in-depth analysis:

- Stages of corporate citizenship

Turning to an operational approach, the following framework focuses on the decision-making processes and learning in companies. The value of this framework in relation to characterising the companies' sustainability strategies is, therefore, its focus on patterns of behaviour and the emergent strategies:

- LCM capability model

In the following section, each framework is briefly described and their strengths and weaknesses are discussed. Based on this discussion, a conceptual framework is developed in section 8.5. This framework is used in the analysis of Grundfos, B&O and Danfoss PE in section 8.6. The chapter ends with a discussion of the findings and conclusion on how Grundfos, B&O and Danfoss PE sustainability strategies can be characterised.

## 8.1. CORPORATE SOCIAL RESPONSIBILITY AS SHARED VALUE

The first framework is Porter and Kramer's (2006) conceptual framework for understanding how companies strategically can address CSR. Porter and Kramer (2006) focus primarily on the social aspect of CSR in their framework. The aim is to help companies understand and identify the social consequences of their business and enable them to discover the potential to benefit themselves as well as society through setting a strategic direction. Porter and Kramer argue that even though companies today have improved their environmental and social efforts, they have not been as successful as they could have been. This is because they look upon business and society as two opposing forces, where in reality they are interdependent. Secondly, companies think of CSR in generic ways instead of in a way that fits with their business strategy. As a result, the companies take a responsive approach to CSR, which is neither strategic, nor operational, but cosmetic. In such cases the companies' focus on public relations, media campaigns and CSR reporting often ends as aggregated stories of uncoordinated activities that demonstrate the social responsibility of the company. Typical for this kind of organisation is also that CSR initiatives are isolated from operating units, and the social impact of the company is scattered among different often unrelated efforts and stakeholders (Porter & Kramer, 2006).

Porter and Kramer argue that strategic CSR is valuable to both business and society, when companies focus on the points of intersection and the possibilities for shared value, i.e. when both society and businesses benefit. Hence, strategic CSR is about strategically choosing which CSR activities to engage in. In order to determine whether an activity presents an opportunity for shared value, Porter and Kramer

(2006, p.85) suggest that companies begin by dividing the social issues affecting the company into three categories:

1. Generic social impacts, which may be important to society, but are neither significantly affected by the company's operations, nor influence the company's long-term competitiveness.
2. Value chain social impacts, which are significantly affected by the company's activities in the value chain, for instance, suppliers.
3. Social dimensions of competitive context, which are factors in the external environment that significantly affect the underlying drivers of competiveness in those places where the company operates.

In Figure 30, the responsive CSR and the strategic CSR are illustrated. Responsive CSR is related to the generic social issues, where companies focus on good corporate citizenship, unrelated to their business—for instance, donating to local organisations. Responsive CSR is also when the when the focus of the company is on mitigating harm, which arises from the company's value chain activities. Strategic CSR is related to the value chain impacts when the company transforms value chain activities to benefit both society and the company. Strategic CSR is also related to creating a social dimension to the value proposition and thereby integrating the social impact in the overall strategy. Porter and Kramer call this strategic philanthropy. Companies choosing strategic CSR will experience both the greatest business benefits and make the most significant social impact (Porter & Kramer, 2006).


*Figure 30: Responsive versus Strategic CSR (Porter & Kramer, 2006).*

The simplicity of the framework with only two approaches towards CSR is, on the one hand, a weakness because it is a rather black and white presentation, where the variations with each of the two approaches are missing. On the other hand, the simplicity pinpoints the necessity of a strategy if the company is interested in gaining benefits from their CSR efforts rather than seeing them as a cost. Furthermore, when mapping the company's engagement in CSR by using this framework, it immediately becomes visual if the company is truly engaged in CSR or whether its efforts are based on coincidental and scattered activities.

One weakness is that it focused merely on the social and economic aspects of CSR, which means that the environmental dimension is left out, and therefore, the framework in its original interpretation may cause sub-optimisation between the three dimensions. However, one could assume that the same rules apply for the environmental dimension of CSR and that an extension of the framework is possible. Despite this weakness, it is assessed as valuable to include because of its emphasis on the need for companies to link CSR to the business strategy and core capabilities, instead of taking a generic approach to CSR.

## 8.2. 3-STAGE FRAMEWORK FOR INNOVATING FOR BUSINESS SUSTAINABILITY

The second conceptual framework is the 3-stage framework for innovating for business sustainability developed by the Network for Business Sustainability (the Network), which is a Canadian non-profit organisation working with sustainability issues aimed at changing management practices. The Network was interested in investigating which activities a company engages in, in order to become more sustainable. According to the Network, sustainable companies (Network for Business Sustainability, 2012, p.4):

- 'Create financial value.
- Know how their actions affect the environment and actively address those impacts.
- Care about their employees, customers and communities and work to make positive social change.
- Understand these three elements are intimately connected to each other.'

Based on a study of 127 academic and industrial sources from a time span of 20 years, the Network divided the approaches that companies take to work with sustainability into three stages, illustrated in Figure 31. In stage 1, 'Operational Optimisation', the company improves its existing procedures by adding environmental and social criteria to the existing quality and profit criteria. This is incremental innovation with attention to doing less harm. In stage 2, 'Organisational Transformation', the company looks for new business opportunities in innovating new products or services introduced in new markets. In stage 3 'System Building', the company is a change agent in society working to benefit and change society, and also benefitting as a company by driving institutional change (Network for Business Sustainability, 2012). The stages of the framework illustrate that in order for a company to move towards working with sustainability in a more comprehensive way, the focus must move away from optimising its own manufacturing processes and incremental improvements aimed at reducing harm (stage 1). The focus must be moved towards thinking in completely new products, services or business models (stage 2) and to engaging with others in partnerships or collaborations, which create a positive impact not only for the company but for the entire society (stage 3).

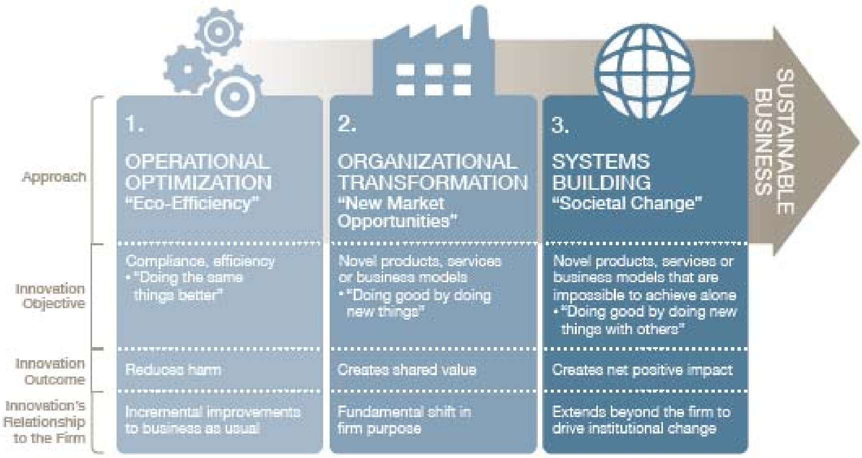


*Figure 31: The 3-stage framework for innovating for business sustainability (Network for Business Sustainability, 2012).*

The strength of the framework is its simplicity as it consists of only three stages that are based on the company's definition of its span of control. The framework is useful when discussing a company's vision regarding sustainability, and it can provide inspiration as to where to direct a company's focus if a company would like to work more with sustainability. Furthermore, the framework allows companies to work with sustainability on different stages in different departments, for instance, which is probably the reality in many companies.

A weakness of the framework when using it for mapping a company's engagement sustainability is its point of departure in innovation for sustainability. This means that the decision of making a change towards sustainable development has been made and as a consequence, the framework does not include companies who have not yet implemented sustainability in their business strategies or practices.

## 8.3. STAGES OF CORPORATE CITIZENSHIP

The focus now turns to a more analytical and detailed framework specifically developed to analyse the level of engagement in sustainability issues by a company. This is the Stages of Corporate Citizenship framework developed by Googins, Mirvis and Rochlin (2007). The framework is a categorisation of companies' development within corporate citizenship, the US concept of what in Europe is more often referred to as CSR or sustainability. The framework is the result of numerous interviews and studies of global companies. The idea is that particular activity patterns exist at different stages of a company's growth and that companies' behaviour and activities become more complex and comprehensive, the more developed their corporate citizenship identity is. As an example, companies just beginning to work with sustainability often do not understand all the relationships they have with society, and often lack both knowledge and mechanisms to respond to the demands and questions that arise. On the other end of the scale, are companies that have made great investments in this area, whose CEO is a pioneer and is leading the way, and whose board of directors, management and employees are fully informed and act accordingly (Googins, Mirvis & Rochlin, 2007).

Googins, Mirvis and Rochlin have categorised five stages of corporate citizenship; from Stage 1 Elementary, which is the lowest stage of engagement, merely focusing on making a profit and complying with legislation; Stage 2 Engaged; Stage 3 Innovative; Stage 4 Integrated, which all require an increasingly higher engagement in sustainability; to Stage 5 Transforming, which represents the highest level of engagement and focuses on changing society towards a sustainable development. The five stages of engagement are illustrated in Table 18, together with the seven dimensions that determine the stage to which a company belongs. In the following section, the elements of the framework are explained.

'Citizenship Concept' is about how comprehensively the company defines its corporate responsibility. Does it merely focus on ensuring jobs and paying taxes, which is the lowest stage, or is the horizon expanded to include environmental protection and stakeholders, or is equal attention given to the triple bottom line? At the top stage of engagement, the company is interested in making changes in society through its business models. 'Strategic Intent' is about the purpose of taking corporate responsibility, where at the lower stages focus is on legal compliance and making sure to sell the products and run the factories. In the later stages, the focus changes to a business case approach where the company, on a project basis, implements projects with a favourable return-on-investment, and in the value proposition, the company's values are included alongside traditional return-on-investment criteria when deciding new projects. At the top stage, corporate citizenship is an intrinsic part of the company's business model.

‘Leadership’ is concerned with the level of engagement from the top level of management. This ranges from leaders that are out of touch with what is happening in the company in terms of sustainable development, to leaders that are informed but not driving the sustainability agenda; from leaders that are on top in the business or even leading the agenda in the entire industry, to leaders who are focused on changing the entire way of doing business.

‘Structure’ concerns the division of responsibility between employees. At Stage 1, the sustainability efforts are fragmented and driven by single staff members; at Stage 2 there are functional divisions with some corporate citizenship responsibilities, but the efforts mostly take place in the specific divisions and are not coordinated across the different departments and divisions of the company. At stage 3, the efforts are organised cross-functionally, and at stage 4, the efforts are integrated vertically in the organisation, and lines of businesses are engaged. At Stage 5, corporate citizenship is part of business, activities cut across and business units and functions are engaged and take ownership.

‘Issues Management’ is related to how the company reacts to the specific issues that arise. This ranges from handling issues as one-offs, to having implemented policies that may not be fully implemented; from having operationalised policies on key issues that actually are important to the company, to having programmes, plans and performance measures, and to being ahead of the issues by planning ahead and anticipating both risks and opportunities.

‘Stakeholder Relationship’ is about how companies engage with their stakeholders; this can be on a unilateral basis that is one-way communication or unilateral basis that is two-way communication, for Stage 1 and 2, respectively. At stage 3, the stakeholders are involved and have the opportunity to influence the business, whereas the company and the stakeholders have a shared agenda at Stage 4 and can create win-win situations. At stage 5, the company works together with the stakeholders on important issues as equal partners.

Finally, ‘Transparency’ concerns the openness of the company regarding financial, social and environmental performance. This ranges from a minimum amount of communication that is required by law (Stage 1), to sporadic communication mostly focused on emphasising good news (Stage 2); from a systematic approach where the company reports on citizenship related issues (Stage 3), to full disclosure of goals and results (Stage 4), and to Stage 5 where the company seeks third party assurance and verification of the reported results (Googins, Mirvis & Rochlin, 2007).

*Table 18: Stages of Corporate Citizenship (Googins, Mirvis & Rochlin, 2007).*

| | **Stage 1: Elementary** | **Stage 2: Engaged** | **Stage 3: Innovative** | **Stage 4: Integrated** | **Stage 5: Transforming** |
|---|---|---|---|---|---|
| **Citizenship Concept** | Jobs, Profile and Taxes | Community, Environmental Protection | Stakeholder Management | Sustainability or Triple Bottom Line | Change the Game |
| **Strategic Intent** | Legal Compliance | License to Operate | Business Case | Value Proposition | Market Creation or Social Change |
| **Leadership** | Lip Service, Out of Touch | Supporter, In the Loop | Steward, On Top of It | Champion, In front of It | Visionary, Ahead of the Pack |
| **Structure** | Marginal: Staff Driven | Functional Ownership | Cross-Functional Coordination | Organisational Alignment | Mainstream, Business Driven |
| **Issues Management** | Defensive | Reactive Policies | Responsive Programmes | Pro-active Systems | Defining |
| **Stakeholder Relationships** | Unilateral | Interactive | Mutual Influence | Partnership, Alliances | Multi-Organisation |
| **Transparency** | Flank Protection | Public Relations | Public Reporting | Assurance | Full Disclosure |

The strength of the framework is its level of detail due to the analytical focus. Furthermore, the framework is based on empirical evidence, which gives a detailed characterisation of a company's engagement in sustainability practices at different levels.

The questionnaire used to gather the data for the framework is still available, and makes it easy for a company to analyse its engagement. To some extent, the framework is also useful for an overview of which dimensions the company should strengthen in order to work more systematically with sustainability. Employees at all levels in the company can use the framework to understand why the company does things the way it does, and the framework can shed light on the fact that a company can be more proactive in some dimensions than in others.

A weakness of the framework is its wording of the *stages* of corporate citizenship, which implicitly refers to a company's strategic journey towards sustainability as a linear progression beginning at stage 1 and ending at stage 5. This is unlikely in reality, as the analyses of the three case companies in the following also illustrate.

Another weakness is that it is not very operational and specific regarding which steps a company should take to work with sustainability on a higher level. The level of detail may, although useful for an analytical purpose, be too overwhelming for a company to gather an overview of its level of engagement in sustainability. The Stages of Corporate Citizenship framework is American in its origin, which is expressed in the name of the framework. At least in Europe, the concepts of CSR and Sustainability are used instead, and there is a better understanding of these terms here, than of corporate citizenship. As an example, Danfoss changed the name of its 'Corporate Citizenship' function to 'Group Sustainability' and its 'corporate citizenship report' to 'sustainability report' because this term is easier to understand for the employees (corporate environmental manager, Danfoss, 2012).

## 8.4. LCM CAPABILITY MODEL

A framework with a more operational focus is the LCM capability model (LCM model), developed by United Nations Environmental Programme (UNEP) and The Society for Environmental Toxicology and Chemistry (SETAC). The aim of the model is capacity-building in organisations, and it highlights that the process and learning towards sustainability is just as important as the outcome. Hence, the model complements other initiatives that measure an organisation's sustainability performance. In consequence, the model focuses on the decision processes in the organisations. The goal is to make decisions with increased awareness of the consequences of the decisions for both stakeholders and the natural environment. The level of performance in the model is therefore based on who is involved in the decision making process, the sources and types of information used, and the key performance indicators used to monitor and measure the effectiveness of the decision (Swarr, 2011). The Capability Model is linked to a traditional plan-do-check-act cycle. However, the 'check'-step is replaced with a 'learn'-step, indicating that learning takes place in the company based on the incidents that occur. The aim is therefore to gradually build the company capacities for each cycle, and for every level in the capability model, suggestions for tools and activities that can further strengthen the organisation's effort within sustainable development are provided (Swarr, 2015; Swarr et al, 2011). In Table 19 the LCM Capability Model is illustrated.

*Table 19: The LCM Capability Model (Swarr, 2011).*

| Level | Descrip-tion | Span of control/ Influence | Metrics | Decision Process | Business Case |
|---|---|---|---|---|---|
| **1 Ad hoc** | Chaotic, disorganised—will not survive in global economy | | | | |
| **2 Qualified** | Predictable projects | Project | Compliance—yes/no<br>Process outputs | Team-based visible trade-offs | Risk avoidance |
| **3 Efficient** | Management system for consistent results | Enterprise | Process inputs/ outputs, Eco-efficiency | Rule-based trade-offs to achieve enterprise goals | Improved operating margins, Labour and resource efficiency |
| **4 Effective** | Value chain performance optimised | Value chain | Cradle to grave, integrated across value chain | Fact-based to anticipate value chain trade-offs | Top line growth, innovative products, new markets |
| **5 Adaptive** | On-going stakeholder dialogue, system innovation | Society | Sustainability measures,<br>Resiliency | Value-based to co-develop business goals and social expectations | Strong balance sheet, Long-term competitive advantage |

The strength of the model is its practical approach to how businesses, through their decision-making processes and learning processes, can improve their efforts in supporting a sustainable development. The model illustrates how and on what basis decision-making processes are happening and what the span of influence is according to different strategic intentions, which is useful for management purposes.

A weakness of the model, in line with the weakness of the Stages of Corporate Citizenship Model is that the wording of the levels is numbered, which refers to an understanding that the journey of working with sustainability is a linear, forward-moving progression. Furthermore, its goal of having increased awareness of the consequences of the decisions for both stakeholders and the natural environment is, of course, worth striving for, but the question is how much the awareness is increased; and it may seem impossible to actually achieve full awareness.

## 8.5. CONCEPTUAL FRAMEWORK FOR CHARACTERISING THE CASE COMPANIES' SUSTAINABILITY AND ECODESIGN STRATEGIES

In order to characterise the sustainability strategies of Grundfos, B&O and Danfoss a conceptual framework is developed in this section, based on the models in the former sections. The framework functions as a guide for which topics are discussed and which questions asked in the interviews, and as a search tool in the analysis of both documents and interviews. As such, the framework is developed entirely for the purpose of the analyses in this chapter. However, companies can use the framework as point of departure for discussing its sustainability strategies. The conceptual framework is illustrated in

Table 20. For the analysis of the empirical data, it is necessary to specify the criteria for the characterisation of the company strategies, and these are given in Table 21. In Appendix E, an overview is given of how the parameters in the conceptual framework are related to the frameworks presented in section 8.1-8.4.

*Table 20: Conceptual framework for characterising the case companies' sustainability strategies.*

| | Ad hoc | Operational optimisation | Organisational transformation | Systems building |
|---|---|---|---|---|
| **Sustainability concept** | Jobs, profile and taxes | Environmental protection | Triple bottom line | Change the game |
| **Strategic intent** | Legal compliance | License to operate | Business case | Market creation |
| **Structure** | Staff driven | Functional ownership | Cross-functional coordination | Business driven |
| **Span of influence** | On case by case basis | Enterprise | Value chain | Society |
| **Stakeholder relations** | Unilateral | Interactive | Partnership | Multi-organisation |
| **Transparency** | Reporting as 'flank protection' | Public reporting | Assurance | Full disclosure |

In the development of the framework, simplicity is emphasised, and the point of departure is, therefore, the three levels of the 3-stage framework for innovating for business sustainability, which are 'operational optimisation', 'organisational transformation' and 'systems building'. However, it is also necessary to include companies not working with sustainability besides what is required by law. Hence, the four levels range from companies not working with sustainability more than what is required by law (ad hoc), to companies working with sustainability from an environmental protection point of view (operational optimisation), companies that have realised that sustainability involves the triple bottom line (organisational optimisation), and companies with sustainability as an integrated part of the business where the company aims at creating change in society (systems building). This is a simplification compared to the LCM capability model and the Stages of Corporate Citizenship, which both operate with five levels. Compared to the CSR as shared value framework, which operates on two levels, the conceptual framework developed in this chapter is an extension. It could be stated, though, that the 'ad hoc' and the 'operational optimisation' levels pertain to the responsive CSR approach, and the 'organisational transformation' and the 'systems building' pertain to the strategic CSR approach in the CSR for shared value framework. In Appendix E, an overview is given of how the four levels of sustainability strategies in the conceptual framework are related to the frameworks presented in sections 8.1–8.4.

Having established the levels of a company's sustainability strategies, the focus turns to the parameters that characterise a company's sustainability strategies. In the selection, emphasis has been placed on parameters that explain how the companies define their responsibility within sustainability (sustainability concept) and what the purpose is of a company's sustainability efforts (strategic intent), as these are assessed to have a significant influence a company's approach to sustainability, based on Porter and Kramer's (2006) studies. The parameter 'Structure' is included in the framework as it covers the organisational set-up with regards to sustainability activities in the company. Recalling the definition of strategy at beginning of this chapter, allocation of resources, i.e. the organisational set-up and budgets, is part of a company strategy. 'Span of influence' and 'Stakeholder relations' are included in the framework as they clarify how the company interacts with society. 'Span of influence' depicts whether the company interacts with society on a case by case basis, depending on, for instance, what topics are in the news, if problems arise in certain areas, or if they systematically include the entire enterprise, the value chain or in the most sustainable scenario, the entire society. 'Stakeholder relations' depicts how communication with the stakeholders takes place—if it is one-way or two-way communication or if collaboration is established. The final parameter, 'Transparency', indicates how transparent the company communicates with the stakeholders concerning financial, social and environmental performance. In Appendix E, an overview is given of how the parameters in the conceptual framework are related to the frameworks presented in sections 8.1–8.4.

*Table 21: Criteria for characterisation of company strategies.*

| | **Ad hoc** | **Operational optimisation** |
|---|---|---|
| **Sustainability concept** | Jobs, profile and taxes:<br>The company defines its responsibilities within sustainability as merely including ensuring jobs and paying taxes. | Environmental protection:<br>The company defines its responsibilities within sustainability as protecting the environment. |
| **Strategic intent** | Legal compliance:<br>Purpose of working with | License to operate:<br>Purpose of working with sustainability is to ensure that the company is |

| | | |
|---|---|---|
| | sustainability is to ensure legal compliance. | continuously able to run its factories and sell its products. Focus is on incremental improvements – doing the same things better. |
| **Structure** | Staff driven:<br>Sustainability efforts are fragmented and driven by single staff members. | Functional ownership:<br>There are functional divisions with some sustainability responsibility, but efforts mostly take place in specific divisions and are not coordinated across departments and divisions. |
| **Span of influence** | On a case by case basis:<br>Interacts with society and stakeholders on a case by case basis depending on, for instance, problems arising in the factory or value chain. | Enterprise:<br>Systematically focuses on the interactions with stakeholders within and in close connection to the enterprise. |
| **Stakeholder relations** | Unilateral:<br>One-way communication. | Interactive:<br>Two-way communication. |
| **Transparency** | Reporting as 'flank protection':<br>The minimum amount of communication determined by law. | Public reporting:<br>Systematic approach where the company reports on sustainability related issues. |
| | **Organisational transformation** | **Systems building** |
| **Sustainability concept** | Triple bottom line:<br>The company defines its responsibilities within sustainability as equal attention should be given to the triple bottom line. | Change the game:<br>The company defines its responsibilities within sustainability as making changes in society through the use of their business models. |

| | | |
|---|---|---|
| **Strategic intent** | Business case:<br>Purpose of working with sustainability is to take a business case approach and find projects with favourable return-on-investment, and include the company's values alongside traditional return-on-investment criteria. Focus is on doing good by doing new things, e.g. products, services or business models. | Market creation:<br>Sustainability is an intrinsic part of the company's business model. Focus is on doing good by doing new things with others. |
| **Structure** | Cross-functional coordination:<br>Sustainability efforts are being organised cross-functionally. | Business driven:<br>Sustainability is part of business and all lines of business are engaged. |
| **Span of influence** | Value chain:<br>Systematically focuses on the interactions with stakeholders in the entire value chain. | Society:<br>Systematically focuses on the interactions with stakeholders in the entire society. |
| **Stakeholder relations** | Partnership:<br>The company and stakeholders have a shared agenda and are able to create win-win situations. | Multi-organisation:<br>The company works together with stakeholders on important issues as equal partners. |
| **Transparency** | Assurance:<br>Full disclosure of goals and results. | Full disclosure:<br>The company seeks third party verification of the reported results. |

The approach for characterising the companies is that first, information is obtained through written, public material, such as annual reports and sustainability reports. This corresponds to analysing the deliberate company strategy or plans, c.f. Mintzberg's definition in the beginning of the chapter. Subsequently, information on how these plans are implemented in practice is investigated in the interviews of key persons. This corresponds to the emergent strategies, or patterns of behaviour, cf. Mintzberg's definition. The analyses of the companies are therefore two-sided, and include both the written and deliberate strategies, as well as their implementation in practice, which is not necessarily in accordance with the written strategies.

The conceptual framework does not depict the journey of working with sustainability as a linear, forward-moving progression, as is the case in particular with the Stages of Corporate Citizenship framework and the LCM Capability model. As such, the conceptual framework is an idealised characterisation, but in practice, companies' sustainability strategies will not match just one of the characterisations, which the analyses in the following section also illustrate. For instance, the ambition level and strategies of a company may not be aligned with the practices of the company. In addition, the company may have a sustainable business idea implying collaboration with several other actors, which would be the top levels of the sustainability frameworks. However, in order to become a reality, the company needs to improve on its own factory site first, which would be at the lower levels of the frameworks. Another reason for companies' working with sustainability on different levels at the same time is due to the constantly developing sustainability agenda. A company may work at an advanced level within a certain sustainability topic, for instance, avoiding child labour. However, with the introduction of a new product in the company's portfolio, the working conditions in the mines in Congo and the issue of conflict minerals may become relevant, which can be an area where the company has no experience at all. In this way, companies can be characterised differently in the frameworks, depending on the sustainability topic analysed.

### 8.5.1. LIMITATIONS OF THE CONCEPTUAL FRAMEWORK

The limitations of the framework must be kept in mind when using the framework for analysing companies. First, by analysing the publicly available company reports, statements and policies, the analysis to a high degree represents the companies' official version of their ambition level and sustainability practices, i.e. the deliberate strategy. These document analyses are the main source for characterising the companies' sustainability strategies. However, such document analyses do not necessarily reveal the actual practices, challenges and frustrations that the employees in the companies face. Therefore, the document analyses are supplemented with information gathered from the numerous interviews conducted at the case companies, related to, for example, the emergent strategies. This combination of methods is visible in the characterisation of the sustainability strategies in the way that the companies on some parameters in the framework have ambitions and intentions matching one level, whereas the actual practices match a different level.

The analyses based on the conceptual framework represent a snapshot of the current sustainability strategies and how they are integrated in practice. This implies that although the conceptual framework can be used to illustrate that sustainability is a journey in the sense that a company can have different strategies on different issues, the framework is not able to illustrate the development over time. For this type of analysis, it is necessary to perform the analysis several times over a period of time. Alternatively, an analysis could be performed of previous versions of a company's annual reports, statements and policies.

## 8.6. CHARACTERISTICS OF GRUNDFOS', BANG & OLUFSEN'S AND DANFOSS POWER ELECTRONICS' SUSTAINABILITY STRATEGIES

This section contains the analysis of how Grundfos', B&O's and Danfoss PE's sustainability strategies can be characterised. The analysis is 'dual' in that first, an analysis is conducted based on publicly available documents and websites. This constitutes the analysis of the deliberate strategies. It is supplemented with information from interviews with employees at the three case companies concerning how these deliberate strategies are implemented in practice. This constitutes the analysis of the emergent strategies.

The guide for the analysis is the conceptual framework developed in section 8.5. The characterisation of the case companies is plotted in the conceptual framework at the end of each analysis section. When a case company is working with the same sustainability parameter, but on different levels in, for instance, different departments, both levels are plotted in the conceptual framework.

### 8.6.1. GRUNDFOS

In this section, Grundfos' sustainability strategies and how they are integrated in practice are analysed. A summary of the analysis is illustrated in Table 22, and each parameter of the conceptual framework is elaborated below.

#### 8.6.1.1 Grundfos: Sustainability Concept

Grundfos has worked with sustainability issues since the foundation of the company in 1945, and today, Grundfos has a vast amount of policy and strategy documents describing its view of sustainability (see Table 8 in Chapter 7) (Grundfos, 2010). Sustainability is part of The Grundfos Purpose, which is the mission and vision of Grundfos (Grundfos, n.d., e): 'Grundfos is a global leader in advanced pump solutions and a trendsetter in water technology. We contribute to global sustainability by pioneering technologies that improve quality of life for people and care for the planet.' Sustainability is one of The Grundfos Values, which make up the foundation on which Grundfos runs its business (Grundfos, n.d., d):

> 'Sustainable – Grundfos runs its business in a responsible and ever more sustainable way. We make products and solutions that help our customers save natural resources and reduce climate impact. We take an active role

> in the society around us. Grundfos is a socially responsible company. We take care of our people – also those with special needs.'

The Grundfos Purpose is further expressed in Be-Think-Innovate, which is Grundfos' promise to contribute to global sustainability (Grundfos, n.d., b, p.8): 'Being responsible is our foundation. We know that we have a responsibility towards the people who are Grundfos, towards the innovative soul of Grundfos, as well as towards the surrounding world. Whatever we do, we make sure that we have a firm and sustainable basis for doing it'. Sustainability is furthermore built-in in Grundfos' Innovation Intent, the Climate White Paper and The Sustainability Strategy.

The above quotations and the fact that sustainability is part of every policy and strategy document underline the importance of the concept to Grundfos. Grundfos defines sustainability as triple bottom line, where it is sought after in order to ensure a healthy economy, and at the same time, take environmental considerations into account and continuously improve Grundfos' social impact, i.e. at the workplace and in the surrounding society (Grundfos, 2012a). Grundfos believes that sustainability is a journey more than an end-result. In the sustainability strategy, six focus areas have been selected for Grundfos' work with sustainability, and here, the triple bottom line approach is also visible. They are 1) Sustainable Product Solutions, focusing on sustainable product solutions within energy efficiency and water, 2) People Competences, focusing on attracting, retaining and developing world-class people that can take on the sustainability agenda, 3) Environmental Footprint, focusing on reducing the energy, carbon, water and chemical footprint of Grundfos in its entire value chain, including suppliers, 4) Community, focusing on making a positive impact on Grundfos' surroundings and creating shared value by supporting community development projects, 5) Workplace, focusing on creating a safe and healthy work environment and attracting a diverse work force, and 6) Responsible Business Conduct, focusing on ensuring legal and ethical compliance (Grundfos, n.d., f). The strategic focus areas reflect Grundfos' principle of thinking globally but acting locally, and Grundfos has developed a business strategy on shared value for both the business and the community. The business strategy of Grundfos is discussed further in the next section.

Discussing sustainability with the employees at Grundfos, it seems that Grundfos has succeeded in ensuring that the employees share Grundfos' understanding of sustainability and environmental considerations. The employees do mention both the environmental and social aspects of sustainability, and they do understand that there are impacts in the entire life cycle of the products they develop and produce. In the specific product development project there is, however, a main focus on reducing the energy consumption of the product in the use phase, as this is the main impact of the product according to the life cycle assessments that have been conducted on the products (product development manager, Grundfos, 2012; senior project manager, Grundfos, 2012; sustainability consultant, 2012; product development manager, Grundfos, 2012; chief NDI, Grundfos, 2012; global programme manager, Grundfos, 2012; chief product engineer, Grundfos, 2012).

From the above, it appears that Grundfos not only takes a triple bottom line approach to sustainability where equal importance is given to the economic, social and environmental dimensions of sustainability. Grundfos takes it a bit further in that they have developed their business strategies around sustainability and aims at creating changes in society towards sustainability. Hence, Grundfos' concept of sustainability is 'systems building' (see Table 22).

#### 8.6.1.2 Grundfos: Strategic Intent

Sustainability is an integrated part of Grundfos' way of doing business. Grundfos' Innovation Intent is Grundfos' guide on how to do business in accordance with Grundfos' Purpose and Values on a long-term and short-term basis. Innovation Intent is illustrated in Figure 32. All new concepts that are being developed at Grundfos must be in accordance with the Innovation Intent, and it clearly illustrates that sustainability must be an overarching consideration. Hence, the aim and content of the Innovation Intent is diffused throughout the strategies at the department level. For instance, in the D&E Department, whose strategy includes considerations about sustainability, is linked directly to the Strategic Intent (product development manager, Grundfos, 2012).


*Figure 32: Grundfos' Innovation Intent (Grundfos, n.d., g).*

In *Grundfos Sustainability Data 2012* Grundfos' approach to sustainability is described (Grundfos 2012b, p.5):

> 'First of all, sustainability is part of our DNA and the way in which we have always done business. It is an essential part of our purpose and values. Secondly, sustainability is a key concept and business driver in Grundfos. We see great business potential in being a provider of innovative and sustainable solutions. Thirdly, sustainability is also a way to manage potential risks and reduce costs throughout our value chain.'

Group President and CEO, Carsten Bjerg, explains Grundfos' focus in sustainability this way (Grundfos, 2012a, p.3): 'We believe that in the future, demand will increasingly shift towards solutions with low climate impact. Acting on climate change is therefore not only the right thing to do – it is also where the future business opportunities lie for Grundfos'. From the two above quotes it is obvious that Grundfos is taking up the challenge of sustainability by making it part of business strategies, and it is in line with what Porter and Kramer (2006) call Strategic CSR, where the company seeks opportunities for both business and society to benefit.

To make sure that sustainability is continuously a key of the company's DNA, Grundfos has, as mentioned among other things, adopted the Sustainability Strategy. One of the focus areas of the strategy is People Competences, where it is the aim to 'create general awareness on sustainability and make it part of the mind-set; e.g. by incorporating sustainability into existing training programmes, and thereby making it a natural part of our understanding and everything we do' (Grundfos, n.d., f).

Besides the Sustainability Strategy, Grundfos work with a Shared Value model, which takes Grundfos' business strategy about 'thinking globally and acting locally' into account. The model highlights four areas, which is a help to identify and prioritise Grundfos' initiatives within sustainability. The four areas are Product, People, Process and Purchase. 'Product' is about delivering sustainable product solutions and at the same time being competitive; 'People' is Grundfos' realisation that Grundfos is made up of people. That means that it is necessary for Grundfos to ensure an innovative and enthusiastic work force, among other things, through creating a good work space and giving the employees the possibility to continuously develop both professionally and personally. 'Process' is concerned with reducing the environmental footprint of Grundfos' operations, logistics and buildings around the world and creating economic growth in the surrounding society. 'Purchase' is about ensuring a high standard among suppliers among others through supplier management and compliance with UN's Global Compact (Grundfos, 2010). Looking at the 3-stage framework for innovating for business sustainability in section 8.2, which discussed shared value creation as an innovation outcome, Grundfos actually brings the concept of shared value to a higher level. In the 3-stage framework for innovating for business sustainability, creating shared value is at the second stage of innovating where the business is concerned with 'doing good by doing new things' on its own. Grundfos is not only 'doing good' on its own, but is engaging in partnerships with customers and other stakeholders and is making an impact and change in society with these stakeholders.

In the conceptual framework Grundfos' definition of the shared value concept would be on the top level, 'systems building'. As an example, in 2010 Grundfos started the 'Grundfos brings Water2Life' programme together with the Danish Red Cross. This is an employee driven sustainability programme aimed at making access to clean drinking water for the world's poorest (Grundfos, 2010). In another example, Grundfos is a partner in a project with the Danish Energy Agency and the Danish Standards. The purpose of this project was to increase the pump efficiency in buildings. The result of the project was an amendment to the Danish building code, demanding that all new buildings have a pump with a variable speed drive installed (chief engineer, Grundfos, 2012). In a third example, in 2011 Grundfos initiated the Act NOW partnership between NGOs, private and public organisations. The aim of the partnership is to promote awareness of available technologies and solutions for reducing energy consumption and $CO_2$ emissions. According to Grundfos CEO, Carsten Bjerg, ‘Act NOW bridges the gap between commitment and action by engaging decision-makers from business, politics and NGOs so that they learn how easy and fast we can create improvements for business and climate issues’ (Grundfos, 2011).

In summary, it is a core part of Grundfos’ business strategy to create sustainable solutions that benefit both society and business. This is not only done on a business case basis but is a driver for the entire business. Hence, Grundfos’ strategic intent is market creation, which labels Grundfos’ strategy as ‘systems building’ (see Table 22). In practice though, it seems that the many strategy and policy documents have a less significant role than what they seem to have in writing. In the specific product development projects the policies and strategies function as an overall guiding principle, and the product developers know what the ‘right’ direction is according to Grundfos. However, if in specific cases it is to costly or time consuming to make the ‘right’ choice and the ‘right’ choice is not set up as a specific requirement, then the projects from time to time do not follow the ‘right’ choice. It simply has to be a fixed requirement in order for the projects to implement it in every project (chief product engineer, Grundfos, 2012). On this basis, the implementation of Grundfos’ strategic intent on the practical level seems to be ‘ad hoc’ in some of the projects, which is illustrated in Table 22.

#### 8.6.1.3 Grundfos: Structure

In 2008 Grundfos established Group Environment and Group CSR. Group CSR was later renamed to Group Sustainability (see Grundfos’ organisational structure in Figure 20 in Chapter 7). Group Environment is working with issues related to the reduction of the environmental impact of Grundfos’ activities and improving the work environment at Grundfos factories. Furthermore, they are involved with setting up and implementing Grundfos’ environmental strategies (environment engineer, Grundfos, 2012). Group Sustainability is the overall umbrella to the outside world on Grundfos’ activities related to all aspects of sustainability and they coordinate development of the sustainability strategy including gathering input from all relevant departments and stakeholders. On a daily basis, their area of responsibility is related to the development and implementation of the code of conduct, the Water2Life programme and, in general, the implementation and coordination of sustainability activities related to the sustainability strategy (sustainability consultant, Grundfos, 2012).

Sustainability is also part of product development at Grundfos. The D&E Department has a D&E strategy, which implies that they are working to develop sustainable products (product development manager, Grundfos, 2012). During the restructuring of the D&E organisation in 2012, as mentioned in Chapter 7, a new support function was established and a 'change agent' with sustainable product solutions was hired. Her responsibility is to operationalise the sustainability strategy and the D&E Strategy, and, among other things, to define what a sustainable product is to Grundfos (change agent, Grundfos, 2013). The restructuring also implied that one of the product development managers, who has a personal drive and interest in working with sustainability and ecodesign, was appointed as head of one part of this support function. The expectations of the product development manager are that in time, sustainability will become part of the support function (product development manager, 2013). On one hand, moving the product development manager away from the specific product development processes implies that his personal drive and interest is moved away from the development projects. On the other hand, it can also be seen as a strategic move in that he now is able to support more projects than he would have as a product development manager.

Even though Grundfos has a formalised approach to sustainability, the analysis shows that many activities related to sustainability happens independently of these formalised departments and in a rather unstructured way. The sustainability consultant explains (sustainability consultant, Grundfos, 2012; author's translation): *This is the great thing about Grundfos—they have this drive and commitment, and arhh this is awesome, we have to do something about sustainability. We are not quite sure what it means but we think it is this…* According to Grundfos' change agent with sustainable product solutions, many activities are happening based on people's interest (change agent, Grundfos, 2013): *… up until now the initiatives—and there are initiatives […] but it's very random and split throughout the organisation. There is no one common line through and it is just by people who are interested in it and willing to do something about it.*

A specific example of the independent sustainability activities is the Grundfos LifeLink project, which was developed without involvement from Group Sustainability (Lau, 2012). Grundfos LifeLink is a water solution for remote communities without access to electricity and water (Grundfos, n.d., a). Another example is that a product development manager has been a catalyst in hiring both the change agent, engaging with different university students and PhD fellows in their work with ecodesign, and in trying to establish a training programme in ecodesign for the product developers (product development manager, Grundfos, 2012; environment engineer, Grundfos, 2012; change agent, Grundfos, 2013). With the sustainability strategy, Grundfos is making an effort to gather the scattered and sporadic activities that have characterised Grundfos activities within sustainability. The sustainability strategy, therefore, represents Grundfos' focus and prioritisation of activities within sustainability (sustainability consultant, Grundfos, 2012). According to a product development manager, the sustainability strategy is providing the guidance on sustainability that has been missing in the Product Development Department (product development manager, Grundfos, 2012; author's translation): *Now we have our strategy and we have needed it, because so far it* [the activities within sustainability in the product development, ed.] *has been sort of what the engineers could come up with.*

In the specific product development projects, the sustainability focus nearly limited to energy efficiency concerns (senior project manager, Grundfos, 2012; chief product engineer, Grundfos, 2012). However, Grundfos is establishing a sustainability index for products with the aim of defining measuring points and a score system to measure the products' sustainability performance, and in this way, include more sustainability considerations in product development. This index includes four areas on which the product is scored: energy efficiency, materials and recycling, and manufacturing footprint. The index is still a prototype and is being tested on pilot projects in 2012 (project manager of the Sustainability Index, Grundfos, 2012).

Despite the formal set-up, the Group Sustainability is still finding its ground in Grundfos. The sustainability consultant explains (sustainability consultant, Grundfos, 2012; author's translation): *We* [the Group Sustainability, ed.] *are very new in an old company. Four years is not much in the organisation. We have become more visible now, because we moved organisationally from where we started in the organisation to directly under the management.* During the formulation of the sustainability strategy, the Group Sustainability was challenged by the many initiatives already taking place. Initially, the Group Sustainability wanted to map the current status of sustainability activities at Grundfos and adopt a strategy before specific sustainability actions were decided. The D&E Department, however, had already included sustainability aspects in their D&E strategy and did not want to wait for the Sustainability Strategy to be adopted before taking action (environment engineer, Grundfos, 2012). Another example is the change agent, who is acting as one person, and no budget was assigned to the position (change agent, Grundfos, 2013; product development manager, Grundfos, 2013). It is questionable what the effect of such a change agent can be if no resources are assigned to the task. The employees are aware of this challenge, and that Grundfos is currently in a process of building up the organisation to match the sustainability strategy (change agent, Grundfos, 2013).

Based on the above, Grundfos' activities within sustainability are, to a high degree, staff driven, and have been scattered throughout the organisation, which places Grundfos' structure at an 'ad hoc' level. On the other hand, there is also a formal set-up where there are departments with specific tasks. These tasks are coordinated cross-functionally, and even at the department levels, sustainability is part of the department strategies, and the departments take ownership of sustainability activities at the department level. This implies that Grundfos' structure is characterised by having elements of all levels of the framework in Table 22.

#### 8.6.1.4 Grundfos: Span of Influence

Grundfos is working with and promoting sustainability in the entire value chain, from the suppliers who are subject to a supplier management system all the way to providing solutions that comply with the customer requirements and to take back the pumps. Environmental considerations are one of Grundfos' considerations, alongside cost and delivery when choosing a supplier, and in purchasing decisions (Grundfos, 2012a). Furthermore, Grundfos has a supplier management system that implies audits at both potential and existing suppliers. These audits include specific social audits focusing on areas within labour standards, employment practices, anticorruption, community impact and sub-supplier commitment. The social audits primarily take place in China (Grundfos, 2012b). According to one of the focus areas of the sustainability strategy, Grundfos wishes to be engaged in the communities it operates in, for instance, by hiring local labour, through doing business with local suppliers, and by engaging in local initiatives (Grundfos, n.d., f). Furthermore, Grundfos is focusing on making close connections with its customers both to understand their needs and to influence the global sustainability agenda, for instance, through media and participation in networks and decision-making fora (Grundfos, 2010).

Last but not least, Grundfos is also concerned with the end of the value chain, namely, to the take back of the products. In 2012, Grundfos ran a pilot study on the take back of pumps. It was a collaboration with wholesalers and installation contractors. The project led to around one tonne of pumps being returned and 90% of these pumps are recycled (Grundfos, 2012a; Grundfos, n.d., c). This take back programme has now become permanent. Programmes like Water2Life increases Grundfos' engagement from being at a value chain perspective to also including the entire society. Hence, Grundfos' span of influence is characterised as being at an 'organisational transformation' to a 'systems building' level in the framework in Table 22.

#### 8.6.1.5 Grundfos: Stakeholder Relations

Grundfos is actively involved with the stakeholders and in the communities in which it operates. Grundfos is committed not only to be influenced but also to influence the stakeholders, communities and the sustainability agenda. In general, it is Grundfos' ambition to engage in open and transparent dialogue with Grundfos' stakeholders (Grundfos, 2012b).

The importance of the employees is underlined by one of the six Grundfos Values, 'Focused on People' (Grundfos, n.d., d): 'Grundfos is our people. We develop the individual. Everyone in Grundfos has passion and potential. Everyone has the power to influence. Everyone must feel respected and valued.' As part of the focus on employees, Grundfos runs programmes for employee development, such as the Talent Engine, which is a programme focusing on identifying and developing the talents amongst Grundfos' employees (Grundfos, 2010).

Naturally, Grundfos' customers are important stakeholders for Grundfos. Grundfos emphasises that a business relationship with Grundfos is a partnership and involves long term support (Grundfos, n.d., i). Grundfos is continuously working on getting a closer connection with its customers both in order to understand their needs better, but also to be able to influence the global sustainability agenda (Grundfos, 2010).

In Grundfos' *Climate White Paper* Grundfos has committed itself to (Grundfos, n.d., b, p.7):

> 'Grundfos will engage more in public affairs to raise awareness about the full scope of climate related issues such as water scarcity, energy consumption, and water disaster management. In the future we will also remain open to partnering with anyone—even our competitors—in order to affect legislation and raise climate concerns relating to our industry.'

The example from above where Grundfos partners up with the Danish Energy Agency and Danish Standards in a project on pump efficiency is an example where Grundfos has influenced the sustainability agenda, which lead to changes in the legislation. On the EU level, Grundfos has also been active together with the business association, Europump, in lobbying for strict energy efficiency requirements in the implementing measures of the Ecodesign Directive (chief engineer, Grundfos, 2012). In the Water2Life and the LifeLink projects, Grundfos has engaged with both employees and NGOs, which has been beneficial for both the communities where the projects were implemented and for Grundfos' business.

From the above it appears that Grundfos is engaging with many stakeholders in partnerships, which implies that Grundfos' strategy towards stakeholders is 'organisational transformation' (see Table 22).

#### 8.6.1.6 Grundfos: Transparency

'What gets measured gets done', is the way Grundfos describes its sustainability activities (Grundfos, 2012b, p. 28). In the *Grundfos Climate White Paper,* Grundfos has committed itself to communicating about the progress and providing full transparency (Grundfos, n.d., b). Therefore, reporting is an important way for Grundfos to monitor, secure continuous improvement and communicate about its activities. *Grundfos Sustainability Data* is Grundfos' progress report on both Grundfos' Sustainability Strategy and the UN Global Compact. The Global Reporting Initiative (GRI) and UN Global Compact's ten principles are used as a yardstick for reporting on non-financial issues. Furthermore, Grundfos is reporting on its $CO_2$ emissions according to scope 1 and 2 in the Greenhouse Gas Protocol. In the *Grundfos Sustainability Data* report, Grundfos invites all stakeholders to contact Grundfos with comments, questions and any suggestions they may have. An independent auditor assures the report (Grundfos, 2012b).

Based on the above it is clear that Grundfos' ambition is to provide full transparency in its communication to the stakeholders and society in general. Hence, Grundfos' strategy towards transparency is 'systems building' (see Table 22).

#### 8.6.1.7 Grundfos: Summary

An analysis of Grundfos' sustainability strategies and how these are integrated in practice (summarised in Table 22), shows that Grundfos has very high ambitions when it comes to sustainability. Sustainability is part of Grundfos' business strategies, as Grundfos seeks opportunities for both business and society to benefit. Grundfos is aware of its responsibility towards society concerning Grundfos' impact but also concerning being able to influence the global agenda and promoting sustainability practices.

However, looking from the outside at the vast amount of policy documents, values, white papers and strategies related to sustainability, it is a confusing picture. Although the content of the documents is aligned, the number of documents makes it a challenge to find out how the documents relate to each other and to get a complete overview of Grundfos' aim and goals. It seems that Grundfos has realised this as well, and the Sustainability Strategy is an attempt to prioritise and focus Grundfos' efforts within sustainability (sustainability consultant, Grundfos, 2012). The structure of the sustainability practices at Grundfos is still work in progress in terms of setting up the organisation and having the necessary procedures, tools and resources in place. Many of the sustainability related activities are still staff driven, and in the specific product development projects, the product developers need fixed requirements in order to integrate the intentions of Grundfos' policies and strategies on sustainability. This is visible in Table 22 in 'Structure' and 'Strategic Intent', where it is visible that the Grundfos strategy varies from an 'ad hoc' level to a 'systems building' level.

In order to accommodate the demand for measurable targets and specific requirements, Grundfos is taking the technical approach and developing a sustainability index as a tool to integrate sustainability concerns in the product development projects. The product developers at Grundfos do need specific and measurable goals in order to integrate any consideration in the projects (environment engineer, Grundfos, 2012; chief product engineer, Grundfos, 2012). Therefore, on the one hand this could be the tool to support the integration of sustainability aspects into product development project. On the other hand, sustainability as a concept is not necessarily easy to dissect into measurable goals and requirements. Sustainability includes so called ‘soft’ aspects that can be intangible and it can be difficult to assess what the specific influence of Grundfos’ products is. This is reflected by the fact that Grundfos has experienced some challenges in relation to what measuring points should be chosen to measure a specific product’s sustainability level (environment engineer, Grundfos, 2012; change agent, Grundfos, 2013; sustainability consultant, 2012).

*Table 22: Characterisation of Grundfos’ sustainability strategies and their integration in practice.*

| | **Ad hoc** | **Operational optimisation** | **Organisational transformation** | **Systems building** |
|---|---|---|---|---|
| **Sustainability concept** | Jobs, profile and taxes | Environmental protection | Triple bottom line | Change the game |
| **Strategic intent** | Legal compliance | License to operate | Business case | Market creation |
| **Structure** | Staff driven | Functional ownership | Cross-functional coordination | Business driven |
| **Span of influence** | On case by case basis | Enterprise | Value chain | Society |
| **Stakeholder relations** | Unilateral | Interactive | Partnership | Multi-organisation |
| **Transparency** | Reporting as ‘flank protection’ | Public reporting | Assurance | Full disclosure |

## 8.6.2. BANG & OLUFSEN

In this section, the characteristics of B&O’s sustainability strategies and how they are integrated in practice are analysed. The summary of the analysis is illustrated in Table 23 and each parameter of the conceptual framework is elaborated below.

### 8.6.2.1 Bang & Olufsen: Sustainability Concept

B&O adopted a CSR policy in 2011 in which B&O defines how it sees its role in society (B&O, 2013, p.1): 'Bang & Olufsen considers the environment in a closed life cycle, where waste is a resource, which can be recycled in other products. At the same time, Bang & Olufsen wishes to take an active co-responsibility for the society, which we are part of.' The quote shows that the environment is defined in a comprehensive sense and encompasses environmental issues traditionally related to the production site, environmental issues related to the product and working environment.

B&O has, since 2005, systematically worked with responsible supplier management and this is now part of the CSR policy. This includes a code of conduct that accounts for B&O's values regarding the environment, climate, human rights, labour rights and anti-corruption. Once a year, a supplier risk assessment is performed to point out which suppliers might be in risk of violating the code of conduct. Other activities and focus areas specifically mentioned in the CSR policy are the long lifetime of the products supported by B&O's ability to deliver spare parts up to 12 years after the last product was produced. B&O has certified its production facilities according to ISO 14001 and OHSAS 18001. B&O has initiated an energy savings project with the aim of reducing the energy consumption of the production facilities and buildings by 5% each year. Regarding ecodesign, the focus is put on the energy consumption in the use phase, substitution of chemicals and packaging. Finally, regarding waste, efforts are made to reduce the waste from the production and to secure best possible disposal of worn-out products (B&O, 2013). In addition to the policy, B&O is defining a CSR strategy, which is meant to further define how B&O sees its sustainability responsibility and define specific focus areas (environmental manager, B&O, 2013).

The CSR policy is a fairly new initiative (from 2011) and as such does not seem to have found its ground completely throughout the organisation. As the Director of Global Quality puts it, *From the moment when you make the decision to […] the time you follow it 100%—well, it is a journey* (director Global Quality, B&O, 2012, author's translation). The Chairman of the Board of Directors has been one of two main driving forces in adopting the policy and developing the CSR strategy, as he and the board have been pushing to get the policy formulated and brought to the General Assembly (environmental manager, B&O, 2013). The other driving force is the Danish Financial Statement Act, which in 2008 was changed so companies must now report on ethics (environmental manager, B&O, 2013). During the financial crisis of 2008, the focus was on getting B&O through the crisis, which at B&O led to the implementation of several organisational changes and changes on the management level. The most influential for the environmental work at B&O was the closing of the Environmental Department, which implied that the functions were placed in other departments. Furthermore, there were many changes in employees, who interact with the environmental consultant responsible for environmental issues concerning the products and who decides the more strategic direction concerning environmental issues. The environmental consultant explains the situation from her point of view (environmental consultant, B&O, 2012 author's translation):

> *Suddenly I stood there with this whole new organisation, which had never heard anything about these things, so I had to begin from scratch. […] Well, on a management level everybody has been replaced, […] and their focus has the entire time been to turn the crisis of B&O around. So I could forget about talking about the environment even before I got started—because the focus simply wasn't there. So this has been kind of left to us.*

The manager of the environmental consultant agrees that environmental issues may be given a low priority. However, due to the financial crisis many things have had a low priority and environmental issues is just one of them (senior manager Product Quality Centre, B&O, 2012).

Based on the above statements, the integration of B&O's sustainability strategies in practice and their integration in practice can be characterised as being on an 'ad hoc' level, but the ambitions in the CSR policy are on a 'organisational transformation' level (see Table 23).

#### 8.6.2.2 Bang & Olufsen: Strategic Intent

According to the environmental manager, B&O's CSR strategy, which is currently being developed, can be divided into three steps. These steps will be developed gradually. The first part of the strategy is related to risk management. It concerns CSR compliance and involves the supplier management system and efforts within anti-corruption. The second part of the strategy relates to improvements of B&O's own facilities, products and conduct in general. It involves a revision of the code-of-conduct, a product-environment strategy, anti-corruption and transparency online and a revision of B&O certificates. The third step relates to social responsibility and how B&O defines this concept in connection to its activities. The first part of the strategy has been developed the most, and B&O is reporting on the progress of several issues on part two, but no specific goals or action points have been specified for part three (environmental manager, B&O, 2013).

In August 2011, B&O's CEO introduced a new strategy: Leaner, Faster, Stronger. The strategy should break with the development that B&O is too small to follow the big companies, and too slow to respond to the market like the smaller companies (B&O, 2011; Ritzau Finans, 2011). There are six focus areas in the new strategy: 1) increased focus on sound and acoustics and further strengthening of the automotive business segment; 2) build the new B&O PLAY brand; 3) optimisation of distribution; 4) growth in the BRIC markets; 5) R&D transition—use of partners for audio-video development and sourcing; and 6) quicker and simpler execution (B&O, 2013b). The new strategy implied among other things a trimming of the organisation; B&O should stop benchmarking towards to large companies like Grundfos and Danfoss and consider itself a small entrepreneurial company and as such only focus on aspects that are value-creating or determined by law. Hence, environmental issues, besides what is ordered by legislation, are not prioritised (environmental consultant, B&O, 2012; director Global Quality, B&O, 2012).

There are changes in sight within this area as the Chairman of the Board of Directors is pushing for the CSR policy, and a CSR committee has been established consisting of the Executive Vice President, Operations, the Chief Financial Officer and the director Global Quality. This committee is defining the CSR strategy (senior manager Product Quality Centre, B&O, 2013; environmental manager, B&O, 2013).

In terms of product-related environmental issues, this has traditionally been seen as one aspect among many quality aspects that should be in order at all levels, and customers should not be disappointed. However, quality issues are not used in marketing of the products (senior director Idea Factory, B&O, 2012). B&O has previously set proactive environmental requirements for their products, for instance, the use of brominated flame retardants banned in the 1990s long before it was a requirement by law. Many of these requirements have now become legislation and B&O has only to some degree kept up the pace and developed new proactive environmental requirements, for instance, the phase out of certain types of phthalates (B&O, 2013).

All environmental requirements are set up as so-called mandatory requirements. The environmental consultant responsible for setting up these requirements explains the challenges of improving the environmental performance of products when it is not a prioritised area, and because of the requirement on energy consumption in the implementing measures for televisions, as these are phrased as maximum requirements (environmental consultant, B&O, 2012, author’s translation):

> *When they [the product developers ed.] come here and they receive the environmental requirements, and I tell them that they may at a maximum use—I don’t know—100 W for a 40” TV for instance […] then they design according to the 100 W and not the 60 W, for example—that is what the competition can accomplish or what would give us the A+ energy efficiency label. No, the environmental consultant has written 100 W. But I cannot write the requirement any other way, and then there is no focus on reducing the power consumption to other than 100 W. […] As long as the Product Development Department is only measured by them, finishing the product in time and at a proper quality, we will never get further.*

The senior manager of the Product Quality Centre explains the product developers' focus on the minimum requirements this way (senior manager Product Quality Centre, B&O, 2012):

> *Well, it is also related to how difficult it is to reach the requirements as they are now. Because as long as you have difficulties reaching the current requirements, let's say the requirement in two years. Then you do not think about the requirement applicable in five years, because we can't. The technical solutions are simply not there. And then you close your eyes a bit and hope the some technical solutions will show up. This is how it is right now. IT is really, really, really 'uphill'.*

Based on these statements, it seems that the strategic environmental focus in the product development is on an 'ad hoc' level (see Table 23).

B&O's Faster, Leaner, Stronger strategy and the relatively low focus on product environmental issues point towards an 'ad hoc' strategic intent focusing on legal compliance. However, B&O's CSR strategy efforts indicate that B&O's strategic intent can be characterised as 'operational optimisation' (see Table 23).

#### 8.6.2.3 Bang & Olufsen: Structure

In 2011 the Environmental Department, which was responsible for health, safety and environmental issues, was closed down as part of an overall restructuring of the company (environmental consultant, B&O, 2012). The responsibility for the different parts of sustainability is now divided between a few employees in different departments (see the organisational structure of B&O Figure 24 in Chapter 7). Product-related environmental issues and ecodesign are handled by the environmental consultant in the Product Quality Centre; environmental issues related to the production and working environment, for instance, the environmental management system, is handled by an environmental coordinator and an environmental manager in the Quality Department; and work related to the supplier assessment is managed by the Purchasing Department. This is characteristic of companies having sustainability strategies at an 'operational optimisation' level as the efforts within sustainability are mostly taking place in the specific divisions and are not coordinated across the different departments and divisions of the company. The environmental consultant responsible for product-related environmental issues has initiated different projects to increase awareness on environmental issues. Examples are the engagement in a project with Aalborg University on 'designing out waste' from electronic products and a large poster in the hallway showing the current and upcoming environmental requirements for B&O's products. This illustrates that there are staff driven initiatives as well at B&O, and on this basis B&O's structure is characterised by having elements from both an 'ad hoc' and 'operational optimisation' strategy (see Table 23).

#### 8.6.2.4 Bang & Olufsen: Span of Influence

Based on B&O's efforts on the CSR strategy, B&O is still defining its span of influence on sustainability. It is clear, however, that B&O already is working with sustainability through the management systems ISO 14001 and OHSAS 18001, and through the energy saving project mentioned above. These activities concern the enterprise and its immediate surroundings, which imply that B&O's span of influence is on an 'operational optimisation' level. Because of B&O's efforts within supplier management, there are also activities related to the value chain, implying an 'organisational transformation' characterisation of the span of influence. On this basis, B&O is assessed to use elements from both the 'operational optimisation' and 'organisational transformation' level (see Table 23).

#### 8.6.2.5 Bang & Olufsen: Stakeholder Relations

B&O engages with stakeholders on different levels. First of all, B&O is a listed company, which among other things, means that investor meetings are held following every quarterly report. B&O publishes annual reports including B&O's report on CSR issues. Besides, B&O has elaborated on its CSR efforts and on environmental issues related to production and products. These reports are presented at the Annual General Meeting, where shareholders and other stakeholders can ask questions (B&O, 2013b). On one of these occasions there were comments from the shareholders that B&O's CSR policy could be clarified (environmental manager, B&O, 2013; senior manager Product Quality Centre, B&O, 2013).

B&O is also member of different business associations. As part of the cost cutting exercise in relation to the financial crisis, membership with some of the business associations was terminated. Hence, B&O is now member of one business association concerned with environmental issues, namely the Environment and Energy Group of the Danish Consumer Electronics Association (environmental consultant, B&O, 2012).

In connection with the implementation of the Faster, Leaner, Stronger strategy B&O has established collaborations with different business partners and joined their different areas of expertise. B&O also has close collaboration with the retail network selling B&O products, and during the financial year 2012/2013, a sourcing and R&D team was established in Singapore with the aim of being closer to the Asian sourcing partners (B&O, 2013b).

As seen above, B&O does interact with various stakeholders. With regard to CSR issues, the relation seems to be limited to CSR reporting, but this is discussed at the Annual General Meeting. Hence, B&O has an 'ad hoc' strategy, moving towards 'operational optimisation', towards their stakeholders (see Table 23).

#### 8.6.2.6 Bang & Olufsen: Transparency

Until 2008, B&O produced a short pamphlet every year dedicated to a specific B&O product. The pamphlet contained short stories and information about environmental issues relating to the specific product, and the aim was to present the environmental information in a more interesting and engaging way than just tables in an annual report. In connection with prioritisation of tasks as a result of the financial crisis, it was decided to stop producing the pamphlets (environmental consultant, B&O, 2012).

B&O does CSR reporting according to the UN Global Compact and it is included in the annual report (B&O, 2013). In the report, the annual goals within CSR are listed and the results on last year's goals are presented. This is characteristic for companies working with sustainability at an 'organisational transformation' level (see Table 23).

#### 8.6.2.7 Bang & Olufsen: Summary

The analysis shows that the financial crisis has had a strong influence on the priorities of B&O and only value-creating matters are prioritised. In combination with B&O traditionally not branding its products on environmental aspects, this means that environmental improvements beyond what is prescribed by legislation is not prioritised. Furthermore, the way the mandatory product requirements are set up does not inspire the product developers to move beyond legal compliance. This prioritisation is visible in Table 23, as B&O is placed in the lower to middle level of the framework. The reason why B&O is placed higher on some parameters is the ambitions in the CSR strategy and the CSR policy. This means that the ambition to do more to move towards sustainability is there, but these changes are only beginning and have not yet filtered through the organisation. For instance, the Sr. Technology Specialist states that neither the CSR policy nor the CSR strategy have an influence on the research strategy (senior technology specialist, B&O, 2012 and 2014). In an organisation where a CSR strategy is a core part of the business, this would have an influence even on the research strategy. In this sense, Table 23 reflects the ambition level of B&O just as much as it reflects the actual practices at B&O.

*Table 23: Characterisation of B&O's sustainability strategies and their integration in practice.*

| | **Ad hoc** | **Operational optimisation** | **Organisational transformation** | **Systems building** |
|---|---|---|---|---|
| **Sustainability concept** | Jobs, profile and taxes | Environmental protection | Triple bottom line | Change the game |
| **Strategic intent** | Legal compliance | License to operate | Business case | Market creation |
| **Structure** | Staff driven | Functional ownership | Cross-functional coordination | Business driven |
| **Span of influence** | On case by case basis | Enterprise | Value chain | Society |
| **Stakeholder relations** | Unilateral | Interactive | Partnership | Multi-organisation |
| **Transparency** | Reporting as 'flank protection' | Public reporting | Assurance | Full disclosure |

### 8.6.3. DANFOSS POWER ELECTRONICS

In this section, the characteristics of Danfoss PE's sustainability strategies and how they are integrated in practice are analysed. Parts of the analysis below concern issues that are relevant for Danfoss PE on a division level, but are determined on the Danfoss Corporate level. Therefore, the analyses include references to both Danfoss and Danfoss PE. A summary of the analysis is illustrated in Table 24, and each parameter of the conceptual framework is elaborated below.

#### 8.6.3.1 Danfoss Power Electronics: Sustainability Concept

Danfoss has a broad definition of sustainability, which includes both environmental issues related to production and products and, to a high degree, the social side. Danfoss' corporate environmental manager puts it this way (corporate environmental manager, Danfoss, 2012, author's translation):

*[…] we have a fairly dominating status, not only on Als [in southern Denmark, ed.] where we have our main factory, but also the other places in the world where we are situated. And this means that the values that are at the root of our environmental work are very much based on that we must behave well. Keep one's own house in order, as we call it. We do not have the desire to be frontrunners on environmental issues, but we have to be in compliance with the legislation, of course. And on the areas where it makes sense to us, we will be on the forefront. This is where we can make a connection to the business. […] so you could perhaps use the term 'fast follower' on a lot if the things that we do. And this regards the environmental work, working environment and the social aspects. Except perhaps what you would call social responsibility […]. In this area we have always had a special status and done more than what could be expected.*

Danfoss has formulated both a Corporate Policy Environment and a Corporate Standard Social Responsibility, in which Danfoss defines its responsibility (Danfoss, 2005; Danfoss, 2013). Danfoss takes a holistic view in the definition of environment, which includes the working environment, health and safety and internal and external environment (Danfoss, 2005). In the environmental policy it is further described that Danfoss will (Danfoss, 2005, p.1): 'Promote sustainable development by preventing pollution and eliminating undesirable impacts on the environment and Ensure our efforts are resulting in continuous and measurable improvements in the environment.' Further, the policy emphasises that a precautionary strategy is supported by (Danfoss, 2005, p.1): 'Going further than required by law in restricting the use of substances and processes that might present a potential risk to the environment'. Based on these statements, Danfoss' engagement in sustainability practices is 'organisational transformation' moving towards 'systems building', especially concerning the social aspects.

However, this perception does not seem to have been filtered through the organisation. The environmental coordinator at Danfoss PE explains her view on sustainability like this (environmental coordinator, Danfoss PE, 2012, author's translation):

*This [sustainability, ed.] is actually what we have placed a little higher—by letting Corporate, someone like the corporate environmental manager bring forward the strategy, before we can actually tell that this is what we do. And I have heard the corporate environmental manager talk about several things, but nothing has been brought forward about 'this is how we do.*

When specifically asked about how Danfoss' attention towards environmental issues includes ecodesign, the head of Industry Affairs at Danfoss PE answers (head of

Industry Affairs, Danfoss PE, 2012, author's translations): *Very low. I would say, if we look at our processes and in the production, there it is high. So that I will not underestimate, but we do not use it as image creating in the sales situation and in our products, but in the processes it is assessed fairly high.* Furthermore, the head of Industry Affairs PE adds (head of Industry Affairs, Danfoss PE, 2012, author's translation): *Ever since the crisis struck, focus has been on cash flow. […] And anything that could counteract cash flow short term is not initiated. To start something on environmental issues that would in the first phase only be cost.* Head of Global PE Quality underpins this statement by stating (head of PE Global Quality, Danfoss PE, 2012, author's translation):

> *Well now […] (it) is not really prioritised. It is like 'surely we do', but going all in—I have certainly not noticed that. […] If we begin with the nice red logo and what it stands for. I am not in doubt about what both the Clausen family and the management want it to stand for. I just don't really feel it. I am not in doubt that if we make a bunch of trash, we would be in trouble. So in some way we know that we have to behave well, but it would make life much easier for us if it was one of those milestones. This is what we mean, and this is approximately the level. Then we could easily fill in the frame. I miss that actually.*

Based on these statements, Danfoss PE's view upon the sustainability concept is somewhere between 'ad hoc' and 'operational optimisation' (see Table 24).

#### 8.6.3.2 Danfoss Power Electronics: Strategic Intent

Several statements have been put forward in the interviews at Danfoss that imply that there is or at least there has been a lack of attention from the top level management on environmental issues. The Head of Global PE Quality explains in the above that he misses a clear statement and guidance from the top level management as to which direction Danfoss PE should move. Further, he comments (head of PE Global Quality, Danfoss PE, 2012, author's translation): *As long as we have a certificate, then it is good enough.* This implies a focus on licence to operate and would place Danfoss PE on the 'operational optimisation' level in Table 24. The head of Industry Affairs PE states when asked about where environmental issues are taken care of in the company (head of Industry Affairs, Danfoss PE, 2012, author's translation): *We are a few people who have started to 'kick' our company management, because we believe that these things should come from the top.* The corporate environmental manager agrees that in times of crisis, focus is very much on making it through the crisis, and it is therefore difficult to get the attention of management on issues related to the environment. The strategy that was presented by Danfoss as a reaction to the financial crisis is named 'Core and Clear' and it sets the direction for Danfoss until 2015. This strategy's four point agenda is to 1) sustain the focus on core activities, 2) increase group flexibility, 3) strengthen innovation based on customer requirements and 4) focus on the group's commitment and ability to implement the strategy (Danfoss, n.d.) This would imply that Danfoss' strategic intent is at the 'ad hoc' level.

However, the corporate environmental manager states that Danfoss' management has announced that sustainability is now on the agenda and they have initiated a sustainability strategy, which would imply that Danfoss is moving towards the level 'organisational transformation'. But even so, he stresses that it will take some effort to get the strategy and the related project accepted (corporate environmental manager, Danfoss, 2012): *It is also a political exercise to get the right people entering the scene at the right time.* However, during the financial crisis of 2008, Danfoss adopted a Climate strategy called 3x25. The strategy implies that Danfoss will reduce its $CO_2$ emission by 25% and increase the share of renewable energy by 25% by 2025, compared to 2007. Even though parts of the strategy were put on hold in order to first get the company through the crisis, the strategy does show engagement in improving the environmental footprint of Danfoss. The corporate environmental manager statement that when a connection to the business can be made, Danfoss is interested in being at the forefront (see quote in section 'Sustainability Concept'), implies a business case approach, which is an 'organisational transformation' strategy. However, no specific examples of this have been found during the study for this paper to back up this statement, and therefore, Danfoss PE's overall strategy for sustainability practices is assessed to be at the 'operational optimisation' level.

Based on the above, the strategic intent of Danfoss PE includes elements from both the 'ad hoc' and 'operational optimisation' level (see Table 24).

#### 8.6.3.3 Danfoss Power Electronics: Structure

At Danfoss, the work related to environmental issues is divided into a corporate function and a Quality Department in each division (see the organisational structure of Danfoss and Danfoss PE in Figure 26 and Figure 27 in Chapter 7). The corporate function is responsible for setting the strategic direction of Danfoss' overall environmental work, setting up policies and implementing different projects on group level. The Quality Department in each division is responsible for, among other things, the internal and external environmental issues for each division, such as work environment and the environmental management system. The PE Quality Department is not involved in environmental issues related to product environment, besides the standards in the environmental management system (environmental coordinator, Danfoss PE, 2012; head of PE Global Quality, Danfoss PE, 2012; corporate environmental manager, Danfoss, 2012). These standards are a design guideline for product development, which is currently being updated by the Corporate Environmental Department and an environmental checklist. According to the project manager interviewed, this environmental checklist is used by the product developers, at the point in the development process 'request for release', where it is verified that all requirements are met. However, the product manager did not know the checklist herself but was made aware of it when preparing for the interview (project manager, Danfoss PE, 2012). Thus, it seems that Danfoss has set up a structure where different functions are responsible for different environmental areas, which implies that Danfoss PE's structure is characterised by 'operational optimisation'. In practice, though, it is questionable how the tools in the management systems are used, which implies a more 'ad hoc' structure.

There are no overall corporate rules on product environmental issues, but this is left to each division to decide and, hence, each division may have a different strategy. Typically, it is the product development project groups who ensure that the products are in compliance (corporate environmental manager, Danfoss, 2012). However, based on the interviews, it has been difficult to identify who specifically is in charge of whether the products are in compliance with the Ecodesign Directive. When asked, the head of Industry Affairs PE replies (head of Industry Affairs, Danfoss PE, 2012, author's translation):

> *The worst part is probably that if you ask around, then there isn't really anybody. You cannot put a name to it. It is hard. […] When we get such a new challenge, there are some who will be aware of it and then we will discuss how to solve this. It can seem a bit ad hoc, but there are after all some functions that ensure that these things are being taken care of.*

On this basis it is difficult to determine if Danfoss PE's structure is on 'ad hoc' level or if it is 'operational optimisation'.

At the corporate level, Danfoss has initiated a project on developing environmental product declarations (EPD). This is in an attempt to integrate more environmental considerations in the product development process. For the development and implementation of this project, the Corporate Environmental Department has decided to collaborate with external consultants. This is decided in order to ensure high expertise within product development and the latest trends within product environment and to ensure impartiality (corporate environmental manager, Danfoss, 2012). It is characteristic for companies with an 'operational optimisation' strategy to hire external help to implement and facilitate projects.

In summary, Danfoss and Danfoss PE have set up some standards and product requirements. It is, however, unclear how these are used in practice, and as the head of Industry Affairs PE puts it, it may seem a bit ad hoc. The Environmental Department on the PE level is not involved on a practical level and hence, the responsibility is left to the product developers. From the section 'Strategic Intent' it appeared that lower level management is pushing the higher level management for some direction on product related environmental issues, and therefore, the practice seem to be staff driven, which is characteristic for companies working with sustainability on an 'ad hoc' level. On this basis, Danfoss PE's sustainability strategies for the parameter ‘Structure’ are on an ‘ad hoc’ to ‘operational optimisation’ level (see Table 24).

#### 8.6.3.4 Danfoss Power Electronics: Span of Influence

From the ‘Corporate Policy—Environment’ it appears that Danfoss will promote greater environmental responsibility by (Danfoss, 2005, p.1), ‘Making environmental demands on materials, products and services through dialogue and cooperation with suppliers and contractors’. The Corporate Citizenship Report (Danfoss, 2011) states that all suppliers must sign Danfoss’ Code of Conduct and are categorised in a risk-effect matrix. The categorisation of the supplier in this matrix determines how often the supplier is audited. This implies that Danfoss has defined its Span of Influence to include the value chain, which is characteristic for companies working with sustainability at an ‘organisational transformation’ level (see Table 24).

#### 8.6.3.5 Danfoss Power Electronics: Stakeholder Relations

Danfoss on the corporate level is engaged with several of the local communities where Danfoss is situated all over the world. In Mexico for instance, efforts are taken together with other companies to reduce crime in the area, and Danfoss has adopted a school in the community. At the school they are working with fundamental values such as the importance of education and a well-functioning family (Danfoss, 2011).

In a Danish context, Danfoss is engaged in the Project Zero in Sønderborg municipality, which is a project aimed at making Sønderborg municipality $CO_2$ neutral in 2029. Danfoss was one of the initiators of the project and the chairman of one of Danfoss foundations is also chairman of this project. For Danfoss this project entails activities related to both reducing energy consumption at the factory sites and increasing the share of renewable energy consumption. This is also part of Danfoss’ 3x25 Climate Strategy (corporate environmental manager, Danfoss, 2012).

Danfoss PE is involved with different business associations and CEN ELEC, which is an organisation for standardisation. Here Danfoss PE is involved together with other companies in developing the standards following the Ecodesign Directive (senior R&D Standardisation, Danfoss PE, 2012).

Since 2011 Danfoss has been using social media to communicate with the stakeholders; for instance, Chinese social media has been used to recruit new employees (Danfoss, 2011).

It appears from the above that Danfoss is highly engaged with the various stakeholders, and on this basis, Danfoss has an ‘organisational transformation’ strategy towards the stakeholders (see Table 24).

### 8.6.3.6 Danfoss Power Electronics: Transparency

Danfoss ‘Corporate Policy Environment’ emphasises that Danfoss participates ‘in open and positive dialogue with the outside world about the results of our environmental affairs’ (Danfoss, 2005, 1). Danfoss reports on sustainability issues according to UN Global Compact’s ten principles. The reporting follows the Global Reporting Initiative’s guidelines (GRI) and the ISO 26000 standard on social responsibility and is verified by an independent third party (Danfoss, 2011). The reporting is done annually in the Corporate Citizenship Report, and from 2012, in the Sustainability Report. However, the 2012 Sustainability Report does not follow the GRI guidelines and has not been verified by a third party (Danfoss, 2012). Hence, Danfoss can be characterised as ‘systems building’, but in 2012 has moved to the level ‘organisational transformation’ due to the missing third party verification (see Table 24).

### 8.6.3.7 Danfoss Power Electronics: Summary

In summary, Danfoss has especially been concerned with the social aspects of sustainability at a very high ambition level. Many policies, strategies and tools related to climate, environment and environmentally product development are adopted or being developed. However, a strong focus has been on getting the business back on the right track after the financial crisis, and in practice, it has been difficult to get environmental issues prioritised. At the PE Division level, they miss a clear statement and guidance from the top management. This seems to be changing now since new tools and strategies are being developed. This has not yet, however, been implemented and adopted throughout the organisation. This is visible in Table 24, illustrating Danfoss PE’s engagement in sustainability practices, which is on a low to mid-level.

*Table 24: Characterisation of Danfoss' sustainability strategies and their integration in practice.*

| | **Ad hoc** | **Operational optimisation** | **Organisational transformation** | **Systems building** |
|---|---|---|---|---|
| **Sustainability concept** | Jobs, profile and taxes | Environmental protection | Triple bottom line | Change the game |
| **Strategic intent** | Legal compliance | License to operate | Business case | Market creation |
| **Structure** | Staff driven | Functional ownership | Cross-functional coordination | Business driven |
| **Span of influence** | On case by case basis | Enterprise | Value chain | Society |
| **Stakeholder relations** | Unilateral | Interactive | Partnership | Multi-organisation |
| **Transparency** | Reporting as 'flank protection' | Public reporting | Assurance | Full disclosure |

## 8.7. CONCLUSIONS

The aim of this chapter was to analyse the following question: *How can Grundfos', Bang & Olufsen's and Danfoss Power Electronics' sustainability strategies be characterised?* To guide the analysis, a conceptual framework was developed, which divides the characterisation of the companies' sustainability strategies into four levels. Using the framework to analyse the three case companies, it is not possible to characterise any of the companies as working with sustainability at one level exclusively. The sustainability strategies in all companies hold at least three levels of characteristics. This underlines the point raised in section 8.5, that the characterisation on four levels represents an idealised world view and that in reality, companies are working with sustainability at different levels at the same time. It is also a confirmation of that companies work with different types of strategies, the deliberate strategies, which manifest themselves in for example the written documents, and the emergent strategies, which are reflected in the actions and behaviours of the employees. It also underlines the point that sustainability is not necessarily a journey with a continuous linear progression. This is exemplified, for instance, by all companies having established CSR or sustainability strategies, which are not reflected in the organisational structure yet, or by Danfoss deciding no longer to have their sustainability report verified by a third party, or by B&O that despite the CSR strategy has closed the Environmental Department and spread these functions to other departments.

The analysis of Grundfos, B&O and Danfoss PE showed that the three companies are working with sustainability on different levels. B&O and Danfoss PE have been challenged significantly by the financial crisis and have given low priority to sustainability issues. The strategic intent of both companies is characterised as 'license to operate' and 'legal compliance', which is at the 'operational optimisation' and 'ad hoc' level, respectively. Grundfos has found a business model in sustainability issues, and their strategic intent is at the 'systems building' level. In practice, however, Grundfos is, for some projects, working on an 'ad hoc' level. The differences in strategy are visible in several ways. Grundfos has included sustainability as a focus point in more than twice as many strategic documents compared to both B&O and Danfoss. The differences are also visible in the formal organisation of the sustainability work. In Grundfos, a specific Sustainability Department and job entitled change agent with sustainable product solutions are established, whereas in B&O, the Environmental Department was closed down, and in Danfoss PE, it is unclear who is in charge of compliance with the Ecodesign Directive. These differences also imply differences in the working conditions related to sustainability issues. However, the analysis shows that on the operational level the employees are faced with similar challenges no matter the ambition level of the company. Some of these common characteristics are elaborated below.

All three case companies are working with CSR or sustainability strategies, which are examples of the deliberate strategies. Grundfos has adopted a sustainability strategy, and B&O and Danfoss are currently developing a CSR strategy and sustainability strategy, respectively. A recurring reason seems to be that the ambition level of the strategies is not yet reflected in the organisation. This is a cause of frustration among the employees in all three companies, but in both B&O and Danfoss, the strategies and policies are also a long requested guiding point from the management. In the case of Grundfos and Danfoss PE, the sustainability work is, besides the strategies, also manifested in the development of tools, e.g. the sustainability index at Grundfos and the EPD and the update of design guidelines at Danfoss. No matter whether the company is working mostly with sustainability from a staff driven point of view or from a more strategic level, the ambition level seems to be higher than the actual practice. As an example, the majority of Grundfos' characterisation pertains to the 'systems building' level, but the way the work with sustainability is structured bears elements of all four levels in the conceptual framework, from 'ad hoc' to 'systems building'. This underlines the fact that working with sustainability is a journey and it is possible to go both back and forth in engagement level in sustainability. In B&O's and Danfoss PE's case, the negative impact of the financial crisis caused the ambition level to drop and the sustainability issues to be prioritised lower. In Grundfos a recent organisational change implied the appointment of a change agent within sustainable product solutions. Even though this indicates an increased prioritisation of sustainability issues related to products, the change agent still experiences challenges in terms of having no budget assigned and that she is working more or less on her own.

Characteristic for all three companies is also that the product development and the environmental support functions are separate entities and that there is limited interaction. For example, in the case of Danfoss PE, the PE Quality Department, which also includes the PE environmental functions, is not involved in any product related environmental issues besides the standards in the management systems. Furthermore, even though sustainability is imbedded in the strategy of the Development and Engineering Department at Grundfos, and the change agent is part of the product development organisation, the change agent still experiences resistance from the product developers, and sustainability is considered an add-on.

A general fact for all three companies is also that single staff members tend to be significant drivers in working with sustainability, both in the companies that have a highly formalised structure and policies, and in the companies that have less formalised structures. This is an example of the importance of the emergent strategies. In Grundfos, this is visible by, for example, the product development manager who tries to set up training programmes and hires the change agent. In B&O, the environmental consultant participates in research projects and tries to visualise the environmental requirements on a poster. In Danfoss PE, the management is trying to push the agenda on the corporate level towards setting higher ambitions regarding sustainability.

All three companies have well established reporting traditions on sustainability issues and report openly about both goals and results. This may be due to a general tendency, in Europe especially, to report openly about such company matters.

In summary, all three companies are working with sustainability issues and product related environmental aspects. Even though the companies have different sustainability strategies, they are facing some of the same challenges; and some of the drivers for working with ecodesign seem to be similar. In the following chapter, the drivers and the barriers for working with these aspects are analysed in more detail.

## 8.8. REFERENCES CHAPTER 8

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# CHAPTER 9. DRIVERS AND BARRIERS OF ECODESIGN

Building upon the former chapter, the analysis of the actual practices in the companies is taken one step further in this chapter. The focus is on an analysis of the underlying reasons for working with ecodesign in the enterprises and the particular role of the Ecodesign Directive. Hence, the aim of this chapter is to answer the research question: *What are the drivers and barriers of ecodesign in Grundfos, Bang & Olufsen and Danfoss Power Electronics and what is the influence of the Ecodesign Directive?*

For this purpose, a conceptual framework illustrating the determinants of ecodesign is used for both the data gathering process and the presentation of the findings. Originally, the framework illustrates the drivers and barriers of eco-innovation, but the framework is useful for illustrating the drivers and barriers of ecodesign too, as eco-innovation and ecodesign are complementary to some degree and partly overlap. Ecodesign and eco-innovation represents two different perspectives on environmental improvements. Ecodesign is part of pollution prevention and builds upon cleaner technology, environmental management and life cycle assessments, among others, and is related to hands-on environmental improvements of manufacturing and products (Remmen, 2000; Bey, Hauschild, & McAloone, 2013; Van Hemel & Cramer, 2002). Eco-innovation takes an innovation perspective on a society level and is more concerned with how eco-innovation can contribute to both economic growth and to environmental improvements at the same time, and is also related to literature within environmental and innovations economics (Cleff & Rennings, 1999; Rubik, 2005; Horbach, Rammer, & Rennings, 2012). The relation and comparability of the two concepts is further discussed in the following section, and the framework is presented in section 9.2.

## 9.1. ECO-INNOVATION AND ECODESIGN

Several different definitions of the term eco-innovation have appeared since the first introduction of the concept in 1996 (Kemp, 2010). In 2007, the European Commission, therefore, initiated two studies with the purpose of creating a conceptual clarification of eco-innovation and to discuss and establish a methodology for developing and selecting indicators for eco-innovations. Both studies develop a definition of eco-innovation. The first study named Measuring Eco-Innovation (MEI) defines eco-innovation as (Kemp & Pearson, 2007, p.7; original highlights):

> ‘Eco-innovation is the production, assimilation or exploitation of a product, production process, service or management or business method

> that is **novel to the organisation** (developing or adopting it) and which **results**, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) **compared to relevant alternatives**.'

The second study named ECODRIVE was initiated as part of the Sixth Framework Programme of the European Commission. In the study, eco-innovation is defined as (Huppes et al., 2008, p.29): 'Eco-innovation is a change in economic activities that improves both the economic performance and the environmental performance of society'.

By both definitions, the environmental performance should be improved by the innovation, while the aim of the innovation is not crucial to whether the innovation can be defined as an eco-innovation. This implies that an environmental improvement can be defined as an eco-innovation even though it was not an intended outcome of a given project, e.g. reduction of material use due to cost reduction will also improve the environmental profile of a wind turbine. The ECODRIVE definition is narrower than the definition from the MEI study as only innovations that improve both environmental and the economic performance are defined as eco-innovations. Another difference is that the MEI definition emphasises that the eco-innovation does not need to be new to the entire society, but it should be new to the user or the organisation. However, this is similar to what can be found in general definitions of innovation.

Ecodesign, as defined in Chapter 3, can be regarded as a subset of eco-innovation as it represents a hands-on perspective focusing on the product development in organisations, while eco-innovation also takes the broader society perspective to environmental improvements. Another difference between the concepts is the discussion of novelty. The definition of ecodesign does not focus on novelty to the same degree as eco-innovation, particularly in the MEI definition of eco-innovation where novelty is a main part. However, when working with improvements, which is the focal point of ecodesign, novelty is an inevitable part of the process.

The potential environmental benefit of an ecodesign or an eco-innovation varies depending on how radical the ecodesign or eco-innovation is. According to Machiba, Bonturi and Pilat (2009), two parameters are defined as influential on the potential environmental benefit of an eco-innovation. These are targets and mechanisms (see Figure 33).

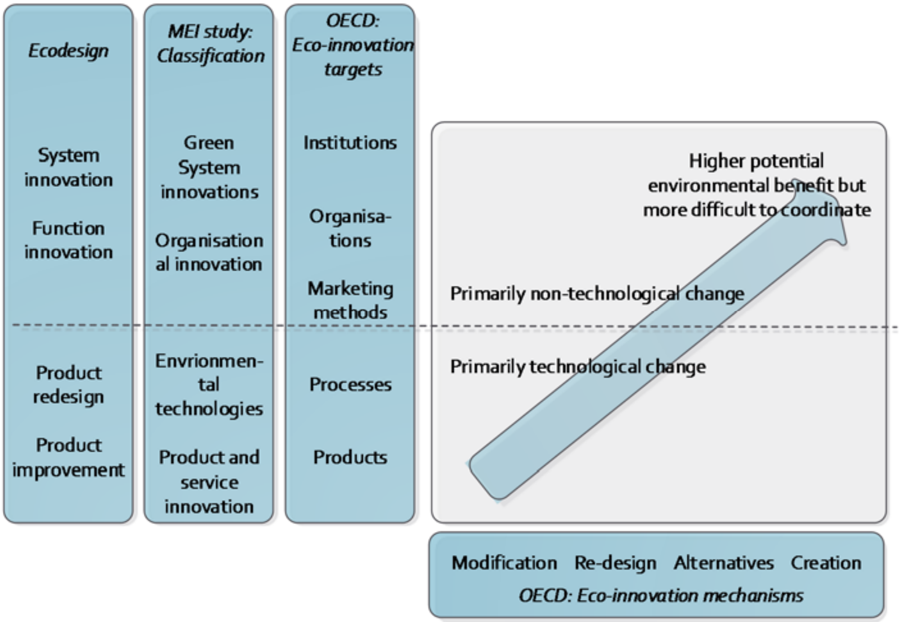


*Figure 33: Parameters influencing the environmental benefit of an eco-innovation. Based on Machiba, Bonturi, & Pilat, 2009, p. 13; Kemp & Pearson, 2007; Brezet & Rocha, 2001.*

Mechanisms refer to the methods used to introduce the eco-innovation. Four mechanisms are identified: modification, re-design, alternatives and creation. Modifications are small, gradual adjustments, and re-design refers to significant changes to a product or service. Alternatives are the introduction of goods or services that substitute other products or processes, but still fulfil the same functional need. Finally, creation is the introduction of completely new products, processes, procedures, organisations or institutions. The innovation’s target is whether the innovation concerns a product, process, organisation or marketing method (Machiba, Bonturi, & Pilat, 2009).

The MEI definition of eco-innovation uses the term classification instead of targets. In Figure 33, the classifications are included to the left of the OECD (Organisation for Economic Co-Operation and Development) targets. The classifications are environmental technology innovations, organisational innovations, product and service innovation and green system innovations. Environmental technology innovations are, for instance, pollution control technologies, cleaning technologies that treat pollution released to the environment and waste management equipment. Organisational innovations for the environment are, for example, environmental management and auditing schemes and chain management. Product and service innovation could be new or environmentally improved products including buildings and services that are less polluting and resource intensive than alternatives, such as, car-sharing. Finally, green system innovation refers to alternative systems of production and consumption that are more environmentally benign than existing systems, for example, renewables-based energy systems (Kemp & Pearson, 2007).

The same reasoning applies to ecodesign. Product improvements are gradual improvements, where the product is the same, while product redesign is when the product concept is the same but entire components are changed or improved. A more radical type of ecodesign is functional innovation, where a product concept is changed to, for instance, a service, and the most radical type of ecodesign is system innovation, where the entire technical system including the product, the value chain, the infrastructure and the institutional structure is replaced by a new one.

The arrow in Figure 33 illustrates that the environmental benefit increases when moving from the bottom left in the figure to the top right. The least radical ecodesigns and eco-innovations concern technological changes and the more radical concern, non-technological changes. Companies are often focused on the technological changes, i.e. the least radical innovations as these most often are within the company span of influence (Machiba, Bonturi, & Pilat, 2009). However, in order to work with sustainability and radical ecodesigns, it is necessary to also include non-technological changes. Such developments imply a gradual expansion of the actors involved, through, for example, partnerships with other companies and organisations. Where a focus on production processes merely involves the company itself, a lifecycle and product-oriented approach involves actors in the entire value chain. Likewise, the incentives for companies' to engage in environmental improvement activities also differ as the companies environmental focus change.

When concentrating on environmental improvements of the production processes, incentives are mostly related to cost reductions, whereas working with the entire life cycle of products, incentives are often company image-related or competitive advantages (Remmen, 2000). The expansion in involved actors and changes in incentives is also reflected in several of the frameworks presented in Chapter 8. For instance in the 3-Stage Framework for Innovation (Figure 31 in chapter 8) that included the company, the value chain and the society as the progression towards sustainability, and in the LCM capability model (Table 19 in Chapter 8) that ranged the incentives from risk avoidance to long-term competitive advantage. In addition, the framework developed in Chapter 8 includes these two parameters, named 'strategic intent' and 'sphere of influence'.

## 9.2. DRIVERS AND BARRIERS OF ECODESIGN

This section focuses upon the drivers and barriers of ecodesign. The framework illustrated in Figure 34 is used in the analysis as a guiding point for analysing the mechanisms that come into play when companies are working with ecodesign, and as such, the framework provides the structure for the analysis. The framework was originally developed by Cleff and Rennings (1999), who with the emergence of Integrated Product Policy in the EU and with this, the interest of policy makers to influence the environmental performance of products, found the need to identify which determinants actually influence and which policy instruments affect eco-innovation of products in companies. Cleff and Rennings (1999), and elaborated in Rennings (2000), identify three categories of determinants of eco-innovation by analysing the environmental economics and innovation economics literature. These are technology push, regulatory push/pull and market pull. Later, the framework was developed further by Rubik (2005) and Horbach, Rammer and Rennings (2012), who added business internal aspects as a fourth determinant of eco-innovation.

For the purpose of this PhD thesis the framework is further supplemented with drivers and barriers of ecodesign found in environmental management literature. In Figure 34, the drivers are illustrated in green letters, while the barriers are illustrated in red letters. It should be noted that what is a driver in some cases can also be barrier in other cases, for instance, regarding company strategies. If the strategy supports ecodesign, it is a driver, but if the strategy focuses on other aspects, it can be a barrier for ecodesign. Likewise, the absence of a driver can be a barrier for ecodesign. The colours in Figure 34 should, therefore, only be interpreted as indicative. In the following, the drivers and barriers within each determinant are presented more thoroughly.

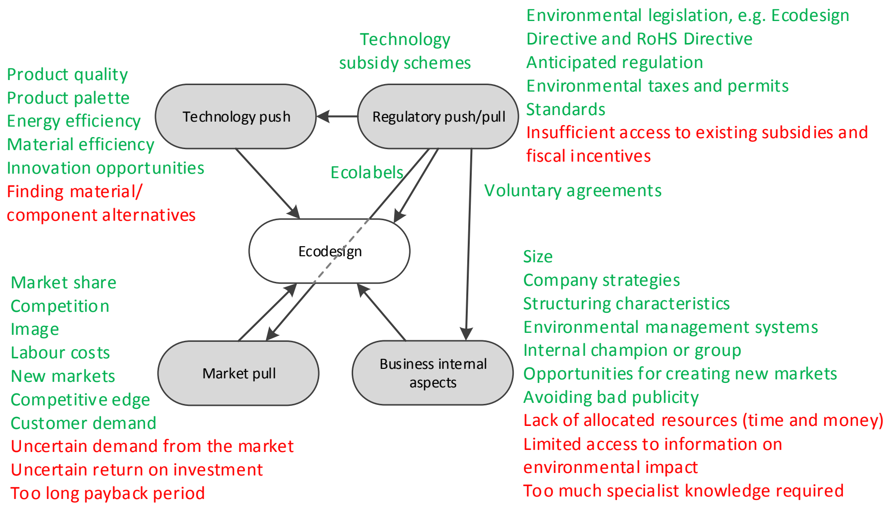


*Figure 34: Drivers (green) and barriers (red) of ecodesign. Adapted from Cleff & Rennings, 1999,193; Rubik, 2005, 171; Horbach, Rammer & Rennings, 2012, 113; Skelton, Patis & Lindahl, 2014; Bey, Hauschild & McAloone, 2013; van Hemel & Cramer, 2002; European Commission, 2011.*

### 9.2.1. REGULATORY PUSH/PULL

Within regulation there are two mechanisms for driving ecodesign and eco-innovation. Either the regulation can create a push through, for example, command-and-control like requirements, through the minimum requirements in the Ecodesign Directive or the RoHS Directive, or it can create a pull by incentivising the companies, for instance, through the Energy Label.

In the innovation economics literature, the role of regulation to stimulate eco-innovation is described as significantly important because of the double externality problem companies are challenged with when eco-innovating (Cleff & Rennings, 1999; Beise & Rennings, 2005). The double externality problem is basically that eco-innovations produce positive spill-overs both in the innovation and diffusion phase. These spill-overs may benefit the environment and the society as a whole but the additional costs are held by the company alone. Therefore, even if the company is successful in its marketing of the eco-innovation, it is difficult for the company to profit from the eco-innovation, in particular, if the knowledge of the eco-innovation is easily accessible to competitors and if the eco-innovation is for the public good (Beise & Rennings, 2005). Therefore, the double externality problem underlines the importance of a regulatory framework in driving eco-innovations.

Traditionally in economics literature, the market-based policy instruments, also referred to as economic instruments, are the main instruments applied to achieve product innovation. Examples of economic instruments are taxes and tradable permits such as the $CO_2$ quotas of the Kyoto Protocol (Cleff & Rennings, 1999). The advantage of economic instruments is that permanent incentives for product improvements are given, whereas by traditional command-and-control regulation, the incentives for improvement disappear once the standards are met. However, Cleff and Rennings (1999) and Rennings (2000) point to the fact that several exceptions to this view have been made. On the one hand, the approach of using standards for driving eco-innovation may not be as inefficient as presumed in the environmental economics tradition. It is possible to improve the efficiency of standards substantially by including rules of permanent reductions or long-term standards, and by introducing a continued process of negotiations in voluntary schemes, so the companies will receive new requirements after each monitoring process.

A similar dynamic approach can be found in the implementation of the Ecodesign Directive, where the requirements in the implementing measures come into force in two steps (so-called tiers), and these are updated regularly. On the other hand, the efficiency of taxes may also be reduced through the political process defining the tax. Basically, the economic instruments function well in situations with perfect competition and full information, but when these conditions are not in place, the situation is changed and other policy instruments may be more efficient. On this note, insufficient access to existing subsidies and fiscal incentives is the fourth most significant barrier for eco-innovation according to a survey by Eurobarometer (European Commission, 2011).

Besides the economic instruments, the regulatory instruments that can push or pull companies' work on ecodesign are traditional command- and-control regulations that set specific standards for product improvements, such as the RoHS Directive (2011/65/EU). A third type of policy instrument is a soft instrument or communicative instrument, which are information instruments such as ecolabels and voluntary agreements between industry and authorities Cleff and Rennings (1999).

Some of the regulatory instruments mentioned above can also influence the three other determinants of ecodesign, namely technology push, market pull and internal business aspects. Ecolabels are an example of a communicative instrument targeting the consumer, and in this way, aiming at creating a market pull for the ecolabelled products. Voluntary agreements are an example of a communicative instrument, which influences the internal business aspects, and subsidy schemes for development of new technology are an example of an instrument influencing the technology push.

Cleff and Rennings (1999) carried out several surveys to further strengthen their conclusions. These will not be described in detail here, but based on these data Cleff and Rennings concluded (Cleff & Rennings, 1999; p.201):

> 'Environmentally innovative firms seem to be less dependent on 'hard' state regulation than other, more passive firms. Thus 'soft' and voluntary environmental policy measures may be sufficient for pioneers. However, 'hard' measures (command-and-control instruments, duties) seem to be still necessary for a diffusion of IPP to non-innovative firms.'

In the environmental management literature, the importance of environmental regulations as a driver for ecodesign has also been analysed. A study by van Hemel and Cramer (2002), who analysed barriers and stimuli for SMEs, finds that government regulation is in the top two of the most influential external stimuli. They emphasise that internal stimuli, such as innovation opportunities and an increase of product quality, are more influential than governmental regulation. A study by Banerjee (2001) that analysed 250 companies from the US concluded that regulatory forces have a high impact on the environmental strategies of, in particular, high-impact industries, such as companies within the chemical industry, compared to, for example, electronics, foods and consumer product industries. Since these two studies were performed, much has changed within the regulation of consumer products, especially in Europe with the adoption of the RoHS, WEEE and Ecodesign Directives. These changes are reflected in more recent studies of the drivers of ecodesign. Demirel and Kesidou (2011), who analyse data from the United Kingdom, conclude that regulations are able to influence end-of-pipe technologies and environmental R&D, whereas the impact of the influence is less clear with regard to integrated, cleaner production technologies, which are modified production facilities and more efficient than previous technologies. Furthermore, Demirel and Kesidou (2011) find that regulation stimulate investments in environmental R&D, which leads to both product and process innovations. Bey, Hauschild and McAloone (2013), who have analysed Danish and US industries, find that legislation is an important driver both for triggering ecodesign and for sustaining ecodesign activities. Furthermore, being at the forefront of legislative demands is also a driver for sustaining ecodesign activities. These findings are supported by Skelton, Patis and Lindahl's (2014) qualitative analysis of the drivers of ecodesign, where legislative requirements are identified as a driver for both initial and particularly for current ecodesign activities.

### 9.2.2. TECHNOLOGY PUSH

According to Cleff and Rennings (1999) and Rennings (2000), the main discussion in innovation economics is whether technological innovations are driven by market demand (market pull) or by the technological development (technology push). They refer to empirical evidence that suggests that both are relevant (Cleff & Rennings, 1999; Rennings, 2000). Technology push drivers are, for instance, the availability of new technologies that improve the environmental performance of the product; this could be within, for example, material or energy efficiency.

Van Hemel and Cramer (2002) analysis shows that innovation opportunities and an increase of product quality are the two most influential internal stimuli for doing ecodesign. Advances in product innovation are also mentioned as drivers for sustaining ecodesign activities by Bey, Hauschild and McAloone (2013), but it is not among the most important drivers. Likewise, it is not found to be a driver in a study by Skelton, Patis and Lindahl (2014). The challenge of finding the necessary material and component alternatives is a significant barrier of ecodesign (Bey, Hauschild & McAloone, 2013).

### 9.2.3. MARKET PULL

Market pull is the second category of determinants that is discussed in the innovation economics literature, which has also been studied in the environmental economics literature (Cleff & Rennings, 1999). Market pull is when customers demand environmentally friendly products or prefer companies with a green or sustainable image. Competition and the potential for creating new markets or increasing market share are also part of the market pull drivers. Horbach, Rammer and Rennings (2012) point out that there is little empirical evidence that the market can in fact be a driver for eco-innovation unless the eco-innovation provides an added value for the customer. This could, for example, be in relation to organic baby clothes or organic food.

These findings are in contradiction with the findings of environmental management literature, where both in the older studies by van Hemel and Cramer (2002), and in the newer studies by Bey, Hauschild and McAloone (2013) and Skelton, Patis and Lindahl (2014), customer demands are a significant driver. Van Hemel and Cramer identify customer demands as the most influential internal driver. Bey, Hauschild and McAloone (2013) identify the competitive edge and customer demands as the two most influential drivers for sustaining ecodesign practices. This is supported by Skelton, Patis and Lindahl's (2014) study. Customer demands are also found to be important as a driver for triggering ecodesign activities in Bey, Hauschild and McAloone's (2013) study, but it was not identified as a driver by Skelton, Patis and Lindahl (2014). Another driver identified by Skelton, Patis and Lindahl (2014) is a push from non-governmental organisations (NGOs).

Turning to the barriers of eco-innovation, uncertainty regarding the demand from the market and uncertain return on investment or a payback period for eco-innovations that is too long are the most significant barriers, in a survey by Eurobarometer (European Commission, 2011).

### 9.2.4. BUSINESS INTERNAL ASPECTS

The fourth category included in the framework in Figure 34 is by Rubik (2005) and Hornbach, Rammer and Rennings (2012). Business internal aspects are, for example, the size of the company, the strategies of the company and how the environmental work is organised in the company. For instance, could an environmental management system be an important driver for introducing cleaner technologies in the company?

In the environmental management literature, business internal aspects are considered a significant driver as well. Van Hemel and Cramer (2002) emphasise the opportunities for creating new markets, whereas Bey, Hauschild and McAloone (2013) highlight the companies' interest in being proactive and avoiding potential bad publicity as a significant driver for triggering ecodesign, whereas for sustaining ecodesign activities internal business aspects are less important drivers. Skelton, Patis and Lindahl (2014) find that especially for current ecodesign activities, the companies' core values and strategies are important drivers alongside having an internal champion or group that can drive the work on ecodesign. Furthermore, top management, an internal champion or group and altruistic values are drivers for triggering ecodesign activities.

Demirel and Kesidou (2011) found that eco-innovations within end-of-pipe technologies and integrated cleaner production technologies are driven by the companies' willingness to invest in and upgrade equipment. Furthermore, it is found that the presence of an environmental management system, especially in the case of an ISO 14001 certification, is a driver for eco-innovations within end-of-pipe technologies and environmental R&D. CSR was found by Demirel and Kesidou

(2011) to fail in being a significant driver for eco-innovation, whereas the size of the company is an important driver for eco-innovation within end-of-pipe technologies, but not within integrated cleaner production technologies and the integration of environmental considerations in product development.

A significant barrier for both ecodesign and eco-innovation is the lack of funds and allocated resources as well as limited access to information on environmental impacts (European Commission, 2011; Bey, Hauschild, & McAloone, 2013). Furthermore, the lack of allocated time in the company and that too much specialist knowledge is required are significant barriers within ecodesign (Bey, Hauschild, & McAloone, 2013).

## 9.3. DRIVERS AND BARRIERS OF ECODESIGN IN GRUNDFOS, BANG & OLUFSEN AND DANFOSS POWER ELECTRONICS

The aim of this section is to analyse the drivers of barriers of ecodesign in the three case companies, Grundfos, B&O and Danfoss PE, and additionally, to analyse the specific influence of the Ecodesign Directive. In the above section, a conceptual framework illustrating drivers and barriers of ecodesign was presented in Figure 34. This framework was applied in the data gathering process during the interviews and in order to illustrate the findings of the analysis. In relation to the definition of eco-innovation and ecodesign, the focus in the analyses is the organisation and how ecodesign is practiced here. Therefore, an analysis of the companies' interactions and influence on the entire society is not included, besides relations that are directly linked to the value chain of the product, or in relation to companies' interaction with authorities concerning the Ecodesign Directive.

The analysis of each company is divided into two parts: one analysing the drivers and barriers of ecodesign on the management level and the other analysing the drivers and barriers of ecodesign on the operational level. This distinction is made because Chapter 8 revealed that even though a company may have a high ambition level and policies in place, these ambitions and policies are not necessarily reflected in the actions and actual practices on the operational level. The aim of this division of the analysis is to be able to catch this duality of, on the one hand, the actions and ambitions of the management, who are the main responsible for the deliberate strategies, as defined in Chapter 8, and on the other hand the operational level, who are responsible for implementing the strategies. Following each company analysis, the findings are summarised in a figure illustrating the drivers and barriers of ecodesign on the management and operational level.

### 9.3.1. GRUNDFOS

#### 9.3.1.1 Grundfos' Management Level

In section 8.6.1 it was emphasised that sustainability and particularly energy efficiency are an integrated part of how Grundfos does business. Acting on climate change is not only the right thing to do, it is also where the future business opportunities are, as CEO Carsten Bjerg puts it. The origin of this business focus is the former CEO, and son of the founder of Grundfos, Niels Due Jensen (product development manager, Grundfos, 2012; sustainability consultant, Grundfos, 2012; chief NDI, Grundfos, 2012). A product development manager explains (product development manager, Grundfos, 2012; author's translation):

> *One of the things that has the biggest influence […] is the management, which ultimately comes from Niels Due Jensen, who has an enormous green focus. It is he who sets the agenda right from the start. It was also he, who back in the day was a bit of a pioneer in the late 1980s, when we wanted to make life cycle assessment […] and we got started with focusing on energy. That came fundamentally from him.*

It is part of the culture of Grundfos to aim for being the best, i.e. better than the competitors on quality and environment, and environment mostly is interpreted as energy efficiency (chief NDI, Grundfos, 2012).

This company culture and way of doing business influence Grundfos' approach towards influencing and implementing legislation. In general, Grundfos sees legislation as a lever for a greater market penetration, and Grundfos is active in influencing the legislation (technology director, Grundfos, 2012). Specifically regarding the Ecodesign Directive, Grundfos has been highly engaged in lobbying for requirements that would benefit Grundfos' business. A global programme manager elaborates on the reasons behind this approach (global programme manager, Grundfos, 2012b; author's translation):

> *It was not because we didn't have products, which were in compliance, but it was simply to—because the requirements in the Ecodesign Directive, and especially in the implementing measures, which apply to our pumps, are so relatively strict. This implies that the market shares are really thrown up in the air. So it is a unique opportunity to conquer market shares from those who may not have as good solutions. […] That is why we have said that it is important that we, before these requirements come into force, launch the best pumps possible.*

The chief engineer responsible for Grundfos lobbying activities concerning the Ecodesign Directive adds that it was already at the end of the 1990s that the energy saving potential of the circulators was discovered. The technologies were being developed and Grundfos wanted to market these new high efficiency circulators more. Therefore, Grundfos together with the business association, Europump, developed the voluntary Energy Label agreement on circulators.

The Energy Label has resulted in an increase in high efficiency pumps on the market from 1.6% in 2004 to more than 30% in 2012 (chief engineer, Grundfos, 2012). Since then, the European Commission started its work on the Ecodesign Directive and its implementing measures, where Grundfos again, together with the business association, has been active in lobbying for requirements that would support Grundfos' position in the market Today, Grundfos has established procedures and an organisation that is working with the new regulations under the Ecodesign Directive, which apply to Grundfos' products (chief engineer, Grundfos, 2012). For instance, Grundfos has taken the presidency of the most important working groups to Grundfos in the standardisation work in Europump, in order to be able to influence the hearing statement to the European Commission (D&E global support manager, Grundfos, 2012).

### The Influence of the Ecodesign Directive on Grundfos' Management Level

According to one of the global programme managers, Grundfos' ambition level is not influenced by the Ecodesign Directive (global programme manager, Grundfos, 2012). Rather, the drivers of ecodesign are an interaction of business internal aspects, technology push, market pull and regulatory push/pull. Grundfos has in its strategy documents, Grundfos Purpose and the Innovation Intent and others, determined that sustainability is part of business and this decision is directly reflected in, for example, the research agenda and product development strategy (product development manager, Grundfos, 2012; technology director, Grundfos, 2012). Furthermore, Grundfos seeks to align the technology development and the business strategies to ensure that there is both a technology push and market pull. Finally, the regulation sets minimum standards, but at Grundfos legislation is, as mentioned, used as a lever to increase market shares (technology director, Grundfos, 2012).

Grundfos has its own electronics factory, which implies that Grundfos has great influence on the technology development. For example, in the case of the circulators, where the increased energy efficiency is due to a technological shift to permanent magnet motors. The permanent magnet was not Grundfos' invention but due to the electronics factory and the expertise, Grundfos was able to refine the technology that made the energy efficiency achievements possible (chief engineer, Grundfos, 2012; product development manager, Grundfos, 2012). In this way, Grundfos is able to influence the technological agenda more than companies dependent on technology developed externally to the company. This ability is highly useful when trying to align the technology development and the business strategies.

As presented in section 8.6.1, the massive focus on sustainability and especially energy efficiency has resulted in a vast amount of mission statements, visions and strategy documents. The intentions of these documents are implemented in the department strategies and through the development of the sustainability index. Internal analyses, however, show that Grundfos not yet has fully implemented procedures and established an organisation to work with ecodesign (product development manager, Grundfos, 2012). The fact that ecodesign is not explicitly expressed in procedures and guidelines is not an indication that they do not work with ecodesign, according to the technology director, because Grundfos is an extremely value driven company, and not everything is expressed in procedures and standards (technology director, Grundfos, 2012). However, Grundfos is currently under restructuring to establish a more organised setting for working with sustainability (product development manager, Grundfos, 2012). In the product development processes a sustainability index for Grundfos' products is currently being implemented in the effort to better integrate environmental aspects in the product development processes (product development manager, Grundfos, 2012).

#### 9.3.1.2 Grundfos' Operational Level

The main guide for the product development teams is the Product Concept Specification (PCS). As the name indicates, this document specifies the product concept in overall requirements. The PCS is further detailed in the Product Requirement Specification (PRS), which is a translation of the PCS into detailed requirements relevant for the product developers. It is, according to a senior project manager, important that all requirements be specified in the PCS including any environmental considerations, as the PCS is *the* guide for the product developers. *[…] it has to be stated here (in the PCS, ed.) otherwise it is not important for the product. And if we have corporate goals, I still think it is important that they are written in there (in the PCS, ed.), because it is still the contents bill for what we must do* (senior project manager, Grundfos, 2012; author's translation).

At Grundfos the scope of a product development project is determined in the four-pointed project star. The four points of the star are time, quality, resources and the specifications of the product. Once these four points are decided, the scope of the development project is locked, and if changes to any one of these points are necessary at a later stage in the product development process, it will entail changes to the other points of the star as well. For example, if changes are made in the specifications, then it may take more time to develop the product or it may be more costly. Grundfos has traditionally had a strong focus on the quality aspect, and it has become an imbedded part of the company culture (senior project manager, Grundfos, 2012; chief NDI, Grundfos, 2012). Likewise, energy has been in focus and it is automatically considered by the product developer, whereas other environmental issues are not part of the company culture in the same way (chief NDI, Grundfos, 2012). For the product development teams, the motivation for working with environmental issues in the product development is the requirements in the PCS. The senior project manager explains (senior project manager, Grundfos, 2012; author's translation):

> *Many of us project managers see the requirements from our business segments as the motivating factor when it comes to taking environmental considerations in the product develop process. Because if there is no demand for it on the market, we may come up with solutions that are too expensive, if we ourselves get the idea that this is something we should do.*

The chief product engineer agrees that it is imperative that environmental requirements as well as any other requirement to the product are not only stated in the PCS, but that management follows up upon the requirements (chief product engineer, Grundfos, 2012; author's translation): *It is not difficult. What you measure is what you get. And if nobody is asking for it, then you are somehow stupid if you spend time on something that no one is asking for. Because then you spend less time on the things that they actually do ask for*. This is supported by the chief NDI, who states that if Grundfos wants to take more environmental considerations than it does currently, then it is necessary to set up mandatory requirements (chief NDI, Grundfos, 2012). Extra requirements, whether they concern environmental or other issues, imply balancing other requirements, and therefore, it is important that a decision be taken about how this balance should be—for example, that an extra cost or development time is acceptable. Energy has traditionally been part of the PCS, and obviously legislative requirements concerning, for example, chemicals (REACH Regulation (EC) No. 1907/2006 and RoHS Directive 2002/95/EC) as well as banned substances are in compliance.

The translation of the PCS into PRS does leave some room for the product developers to decide on, for instance, the material. Often, the choice is made based on considerations about, among other things, cost and functionality, and it is seldom that the product developers have different alternatives where the environmental impact is a parameter for decision making. It is, according to the chief product engineer, based on 80% coincidence if this happens. This is supported by one of the product development managers who state that it is part of Grundfos' culture to take environmental issues into consideration, but it is not structured (product development manager, Grundfos, 2012b). In one example given by the chief product engineer, his curiosity as to what is actually possible to do with ecodesign was evoked by the focus on ecodesign both in the daily press, Grundfos' own communications and by the many students who have done different types of ecodesign projects at Grundfos. In another example, the chief product engineer refers to the power of passionate employees, in that if they see a business opportunity in a certain project or product improvement, they are able to argue for the change and make it happen.

According to several of the interviewed employees, what is needed in order for the product developers to include environmental considerations in the product development process is first of all that it is demanded by the project organisation, through requirements in the PCS, and that these are followed up upon by the project management (product development manager, Grundfos, 2012b; chief NDI, Grundfos, 2012; chief product engineer, Grundfos, 2012).

A further suggestion by the employees are simple tools that the product developers can use themselves. When necessary, experts should be available that are able to use more complicated tools such as life cycle assessments. In general, though, it is the chief product engineer's viewpoint that many ecodesign related activities should be run outside of the product development projects. First of all, because many of such activities are applicable to all product development projects and, therefore, such an activity should be run as a project that covers all products. An example is substitution of materials. Secondly, it is inefficient to run such ecodesign projects as part of a product development process, and it will increase the time of the development project (chief product engineer, Grundfos, 2012).

The responsibility for specifying the PCS is with the programme management. A new product development project begins with some overall goals for the product, and then the programme management starts gathering input on the specific requirements in the PCS from many stakeholders from within Grundfos, for example, the business segments and the sales department. Other inputs come from regulation and the technological development. Fundamentally, Grundfos must have identified a business opportunity for the specific product, which influences what requirements the PCS contains; this also includes considerations about the competitors' products (global programme manager, Grundfos, 2012b). Another global programme manager supplements that the PCS can be seen as the customers' requirements for a product, and the programme management's job is to align these requirements with Grundfos' ambition, and to what is possible to produce (NPI) and develop (NDI) (global programme manager, Grundfos, 2012).

From the product developers' perspective, the customers have not demanded energy efficient solutions, but rather, Grundfos has created the market pull through the Energy Label (product development manager, Grundfos, 2012; global programme manager, Grundfos, 2012b; product development manager, Grundfos, 2012b; chief product engineer, Grundfos, 2012). Grundfos does experience increased demands from the OEM (Original Equipment Manufacturers), who are customers producing big products and systems, and Grundfos delivers parts or smaller systems to these customers, if they are covered by the Energy Labeling Directive (product development manager, Grundfos, 2012). Also, the environment engineer from the Environmental Department experience customer requests regarding life cycle assessments, climate declarations and EPDs. These concern products that are available on the market, and therefore, this information does not reach the product development teams (environment engineer, Grundfos, 2012).

The technological development is on the operational level, also emphasised as a factor that made it possible to achieve the energy efficiency levels required in the Ecodesign Directive (product development manager, Grundfos, 2012b).

Regarding the influence of the sustainability strategy, it does not influence the product development directly. There is, however, focus from the product development management side, and the programme management side, that it is important that the aim and ambition level of the strategy be diffused through to the product development process standards and the PCS, as these are the documents guiding the product developers (product development manager, Grundfos, 2012; global programme manager, Grundfos, 2012b).

Turning the attention towards support functions to the product development process, which work with environmental issues, highlights the difficulties in integrating environmental considerations in the product development process. Two support functions are especially relevant to mention; an environment engineer in the Environmental Department and the change agent within sustainable product solutions. Both positions focus upon making Grundfos' products more sustainable and defining what a sustainable Grundfos product is (environment engineer, Grundfos, 2012; change agent, Grundfos, 2013). The main interaction between the environment engineer and the product development team is through the PCS. The environment engineer, when contacted, provides input to the PCS regarding environmental requirements. Furthermore, the environment engineer is available for answering questions regarding, for example, material choice (environment engineer, Grundfos, 2012). However, just because an environment requirement is stated in the PCS, it does not necessarily mean that the product developers are dedicated to working with this requirement.

The environment engineer gives an example of a project where she had contributed with suggestions for environmental requirements in the PCS concerning recycling. The requirement said that there should be a focus on recycling in the project. When the project was finished, the environment engineer was contacted by an engineer who wanted to know what he could write to the customers regarding recycling, since he saw that there was a focus on recycling in the project. When the environment engineer asked him what had actually happened in the project regarding recycling, the engineer referred to a colleague of the environment engineer, who then referred back to the environment engineer, since she was the one setting up the requirement. According to the environment engineer, this exemplifies that even though recycling was listed as a requirement, it was not used by the engineers. The requirements need to be measurable in order for the product developers to be able work with them. The environment engineer elaborates, *So my experience is that there is not much focus on* *materials and recycling, but I don't swear on it, because I don't really know what is going on* (environment engineer, Grundfos, 2012; author's translation). The chief NDI agrees that the product development teams have a rather peripheral way of working with environmental requirements even if the collaboration with the environmental department is good (chief NDI, Grundfos, 2012; author's translation):

> *It is a good collaboration, it is not that, but I can give you an example. When we develop, quality is a part of our everyday life. We also have a quality department, but it is part of our everyday life—environment is not. […] When we make a construction, then we consider—does this work? Does it comply with our quality requirements? We do not in the same thought consider if it also complies with our environmental requirements. It is not incorporated in the same way.*

Both the environment engineer and the change agent are involved in a series of different initiatives concerning sustainability, such as the development of the sustainability strategy, the material strategy, and a take back and recycling program for Grundfos Pumps. One of the main tasks of both the environment engineer and the change agent is to clarify the sustainability strategy and define what a sustainable Grundfos product is. In this regard, the change agent has found that there is an almost negative touch to sustainability in the organisation and that it is seen as an add-on rather than an integrated and equal parameter to quality and cost (change agent, Grundfos, 2013). Specifically regarding implementing sustainability in the product development process, the environment engineer experiences that it is necessary with specific goals and figures, as it is difficult for the product developers to relate to general concepts and value statements (environment engineer, Grundfos, 2012). Therefore, the sustainability Index is being developed.

An important driver for working with ecodesign and environmental issues in the product development process is according to the environment engineer, a number of passionate employees such as herself, the change agent, and particularly one of the product development managers (environment engineer, Grundfos, 2012). Although the overall job description is outlined by management, they all have a personal interest and drive for improving the environmental performance of Grundfos' products, which is reflected in how they interpret and address their job (change agent, Grundfos, 2013; environment engineer, Grundfos, 2012; product development manager, Grundfos, 2012). As an example, the product development manager, in 2012, collaborated with both master's students and PhD fellows from different universities, who worked with ecodesign in the product development process in different ways, and he was main initiator of employing the change agent and industrial post-doc, focusing on ecodesign practices at Grundfos (product development manager, Grundfos, 2012).

A barrier for working with ecodesign is, according to the change agent, a lack of focus from management. Even though Grundfos has strategies defining the aim and ambitions of Grundfos' work with sustainability, they are not specifically operational. For instance, both the environment engineer and the change agent are challenged with how a sustainable Grundfos product should be defined. Furthermore, the change agent experiences a gap between the ambition level in the many strategy and policy documents and the actual prioritisation of resources. As an example, it is often price that determines a project decision, and sustainability is not even considered, and as mentioned in section 8.6.1, that there is no budget attached to the position of change agent (change agent, Grundfos, 2013).

As a result of these challenges, which the change agent has faced in the endeavour to integrate ecodesign in the product development process, the change agent emphasises the potential of the mandatory requirements in the regulation to actually have an impact on the environmental performance of the products (change agent, Grundfos, 2013).

### The Influence of the Ecodesign Directive on Grundfos' Operational Level

Although the regulatory demands from the Ecodesign Directive on energy efficiency are reflected in the PCS, Grundfos' own ambitions are just as influential. The global programme manager explains (global programme manager, Grundfos, 2012b; author's translation):

> *Definitely! Because of our purpose on sustainability. There is a lot of pride in Grundfos that we have the most innovative pump solutions on the market, and that we do not compromise on quality or function or anything in that direction. […] So you could say that the legislation is just grist to our mill.*

This is supported by the chief NDI (chief NDI, Grundfos, 2012; author's translation), who states that the motivation to work with energy efficiency is *[…] something about being the best.* It is about professional pride both regarding energy efficiency and quality aspects (chief NDI, Grundfos, 2012; product development manager, Grundfos, 2012b; global programme manager, Grundfos, 2012).

The specific influence of the Ecodesign Directive is, therefore, also two-fold. On the one hand, the Directive sets the level for the energy efficiency and the timeline (global programme manager, Grundfos, 2012; global programme manager, Grundfos, 2012b). The chief product engineer sees the Directive as a primary driver, as it has set the timeline for the projects regarding energy efficiency, and this timeline has actually meant that the projects are pressured on time to reach the goals—not in order to comply with the regulation, but in order to be the best on the market (chief product engineer, Grundfos, 2012; product development manager, Grundfos, 2012).

On the other hand, Grundfos would have done many of the same initiatives even without the Ecodesign Directive (global programme manager, Grundfos, 2012; global programme manager, Grundfos, 2012b). One of the reasons is Grundfos' strategy about being the best, and therefore, also the competitors (global programme manager, Grundfos, 2012b; author's translation):

> *You could say that even if the legislation had not come, we would probably have done many of the same things. Maybe not at the same pace, because of the market shares, as we spoke about, but we would have done the same things. […] for my products, we have this big German competitor, with whom we constantly compete about being the best. So we keep each other fit, so that is great. Therefore, we could certainly have done many of the same things, even without this legislation.*

#### 9.3.1.3 Grundfos: Summary

The drivers and barriers of ecodesign in Grundfos are summarised in Figure 35. The green colour represents the drivers and the red colour, the barriers. (M) indicates management level, (O) indicates operational level and bold letters indicate the main drivers and barriers.

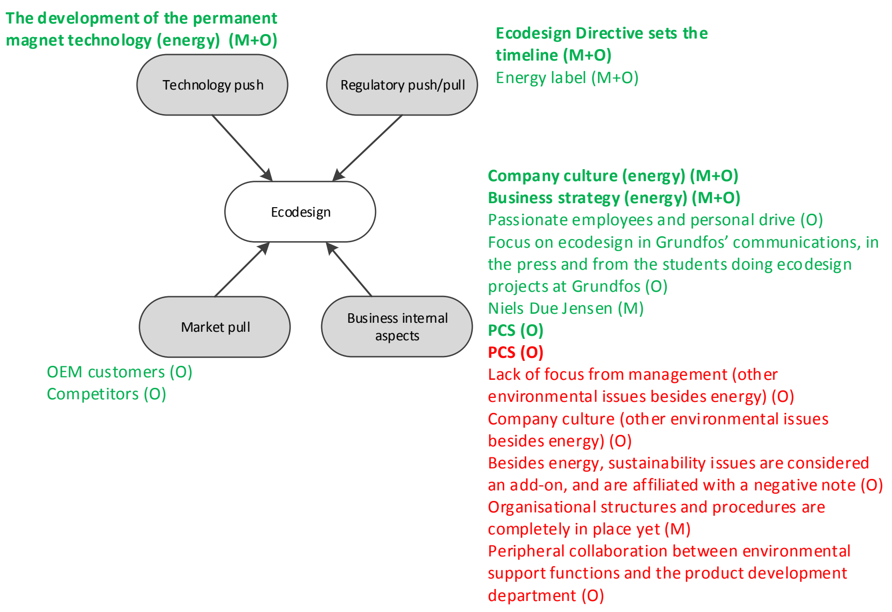


*Figure 35: Drivers (green) and barriers (red) of ecodesign in Grundfos.*

In summary, sustainability and especially energy efficiency is a high priority on the management level. This is manifested in a vast amount of visions, mission statement, policies and strategy documents. The main drivers are that Grundfos has found a successful business model in its strategy of being best, and also in the company culture that was established mainly by the former CEO, Niels Due Jensen. This focus from management, and the fact that energy efficiency is a core part of Grundfos' business strategy, imply that Grundfos is proactive in influencing legislation and ensuring that through strict energy efficiency legislation, it is possible to gain market shares. Furthermore, it entails that the Ecodesign Directive has not influenced the ambition level of Grundfos, but it has set the energy efficiency levels and the timeline. As Grundfos also partly develops the technology, Grundfos is able to create the technology push that is necessary to achieve the desired energy efficiency. The main focus concerning the environment is energy, and other environmental issues have not really been in focus. One of the barriers is that the necessary organisational structures and procedures are not in place yet. As an example, a product sustainability index is being developed and implemented in an attempt to integrate other environmental considerations in the product development process.

On the operational level, the main guide for the product development process is the PCS. As the environmental focus of the PCS primarily concerns energy, it is a driver for the work on energy efficiency, but it is not driving other ecodesign issues. It is, however, important that the requirements are not only stated in the PCS, they must also be requested by the management. In addition, on the operational level, the company culture has a major influence on the issues that are in focus in the product development process, and it has become part of the culture to focus on energy efficiency, whereas it is not part of the culture to consider other environmental aspects. The environmental support functions, i.e. particularly the change agent within sustainable products experiences that the product developers see sustainability as an add-on and it has almost a negative touch to it. One reason could be that the product developers think that it is inefficient to integrate environmental projects into the product development projects.

The peripheral collaboration between the environmental support functions and the product development is also assessed to be a barrier to ecodesign in the product development process. An important driver of environmental initiatives at Grundfos is the passion and personal drive of the employees, whereas a barrier is the lack of attention from management in that so far, other environmental issues besides energy efficiency are not requested by the management in the product development process, and also because no finances have been allocated to the change agent function.

In line with the management level, it is the perception on the operational level that the Ecodesign Directive does not influence the ambition level of Grundfos with regards to energy efficiency. Rather, it is the internal strategies about being the best and about the competitors, which are setting the ambition level. The Ecodesign

Directive has, on the other hand, set the energy efficiency levels and given the timeline for project development. However, even if Grundfos' ambition level is not impacted by the Directive, it is causing some challenges in the Product Development Department in relation to reaching the deadlines in time. The analysis, furthermore, shows that the entire discourse around ecodesign in both Grundfos' own communications, in the press and by the students visiting Grundfos, has inspired at least one of the product developers to consider the environment as a parameter in the product development process, despite it not being a specific requirement in the PCS. Finally, the OEM customers are mentioned as a driver in that they experience requirements from the Energy Label, and therefore, request their supplier, i.e. Grundfos, to be able to comply.

### 9.3.2. BANG & OLUFSEN

#### 9.3.2.1 Bang & Olufsen's Management Level

The dominating understanding at B&O in the management group, which was interviewed for this study, is that B&O is a high-end quality brand and that differentiation is a key term. One of the drivers is that integration of many different features in one product is part of the B&O concept—for instance, DVD and Blue disc players in the television BeoVision 7—and has a floor stand or wall bracket that enables the television to turn and tip (director Global Quality, B&O, 2012). This is all essential in the B&O product concept and is, in addition to the impressive design, part of what differentiates the products from the competition.

Both the director Global Quality and senior director Idea Factory emphasise that environmental issues are an imbedded aspect of quality (director Global Quality, B&O, 2012; senior director Idea Factory, B&O, 2012). The senior director Idea Factory states, *Essentially, we have considered environmental issues as a quality aspect, and it is our opinion that within all quality aspects we wish to be in the better half. This is also our opinion regarding environmental issues; this is part of the quality conception of our brand and as such we shall be in the better half* (senior director Idea Factory, B&O, 2012; author's translation). The discussion of environmental issues in relation to B&O's products is accompanied by the fact that these issues must be in order at all times, but no particular emphasis is placed on environmental issues at the management level. The senior director Idea Factory states that if environmental issues are discussed in the 'ideation phase', which is the preliminary discussion about the design and construction, these topics are brought up by B&O's own employees and not by the external designers that take part in the ideation phase of the product development process (senior director Idea Factory, B&O, 2012).

According to the senior technology specialist, who manages and coordinates all research projects at B&O, environmental topics are not an independent research topic, but it is included indirectly in, for example, research in relation to reduction of standby power consumption of televisions. The research projects initiated are based on either the research strategy or specific problems that the product developers face. The research strategy is decided upon by management and is based on a discussion about what parameters that B&O's products should differentiate in the future Furthermore, he states, 'It is not necessary for us, in order to make products that differentiate us, to do research within that area (environment, ed.). Because environment is mandatory. So of course we have to be in compliance, but it is not something that would differentiate us' (senior technology specialist, B&O, 2012). As mentioned in section 8.6.2, B&O does not market its products on their quality aspect, including the environment, as it should be given that in a quality product environmental issues are also taken care of. This is supported by the senior technology specialist, who state (senior technology specialist, B&O, 2012; author's translation):

> *B&O is not known for flaunting what we have inside the box. So we would not go out there and say; 'by the way we have the most efficient power supply'. […] So if we should make a prioritisation, well the first one is the design—in our prioritisation of what is differentiating our products. And sound and television, or sound and picture and so on. Those are things the customer can see. So you could say that the research manifests itself directly in something you can see. Movable mechanics you can see, but power supplies you cannot see. So I believe, this has an influence on how we prioritise our main field. No doubt about that.*

With regards to the development of the CSR strategy, three main drivers are mentioned (see also 8.6.2). The main drivers appear to be the changes in the Danish Financial Act, which implies that companies must report on ethical issues alongside their financial reporting, and the chairman of the Board of Directors, who pushed for a clearer CSR Strategy (environmental manager, B&O, 2013; senior manager Product Quality Centre, B&O, 2012). However, the director Global Quality emphasises the importance of the connection between being a quality brand and working with issues related to CSR. As B&O is a quality brand it is important for the company to work with CSR and environmental issues as well. As mentioned in section 8.6.2, the CSR strategy is in its early stages and it will be a journey to develop the strategy further. The Global Director Quality states (B&O, 2012; author's translation):

> *[…] Especially with the focus on the customers' awareness of environmentally friendly products. Even though you can say that the biggest group of B&O's customers, probably do not count the last kWh, I still think that it is a message that we want to send. That we are able to produce quality products, branded products that match what others do. For that we must set up goals.*

**The Influence of the Ecodesign Directive at Bang & Olufsen's Management Level**

The influence of the Ecodesign Directive is not particularly present at the management level. The Directive does not have any direct influence on the research strategy (senior technology specialist, B&O, 2012), and in the early design phase, the requirements of the Ecodesign Directive is present through the mandatory requirements in the PRS (senior director Idea Factory, B&O, 2012). The director Global Quality is also presented to the Ecodesign Directive and its requirements through the mandatory requirements, but he is in general aware of the many regulatory demands on the products due to his position of being the superior of the senior manager Product Quality Centre and the environmental consultant responsible for setting environmental requirements. All interviewed directors were aware of and emphasised that B&O is particularly challenged by some of the energy requirements, as B&O's products are high performance, and as such, include more power consuming features than other products covered by the same requirements (senior manager Product Quality Centre, B&O, 2012; senior technology specialist, B&O, 2012; senior director Idea Factory, B&O, 2012; director Global Quality, B&O, 2012). Senior director Idea Factory states (B&O, 2012; author's translation):

> *[…] typically, our products are more complicated than the competitors, i.e. there are more components because we want them to perform better. We use more materials because we want them to look good, etc. So we use more materials in our products, they typically also have higher power consumption, because we want to have a higher performance.*

### 9.3.2.2 Bang & Olufsen's Operational Level

The main guiding element in the product development process is the PRS, which contains all mandatory requirements that the product must comply with. The majority of environmental requirements are set by legislation, and around 7% are internal company requirements, which are either stricter than the legislation or cover other areas not covered by legislation. The environmental requirements are for each product set up by the environmental consultant, who is part of the Global Quality Department, and hence, external to the Product Development Department. She experiences some challenges in relation to including ecodesign in the work of the product development teams and in the organisation as a whole. As mentioned in section 8.6.2, the environmental consultant emphasises both the missing focus from the top management, the project teams and the challenges in relation to the way the requirements in the PRS are set up. Furthermore, the environmental consultant monitors the product related environmental legislation, and she experiences how fast new legislation is adopted all over the world or existing legislation is tightened. This development stresses the need for being proactive in order not to be non-compliant.

The environmental consultant explains (environmental consultant, B&O, 2012; author's translation):

> *Not one month goes by without me emailing someone about a new legislation that has been adopted, or that we now have to put an energy label here or there, or that we cannot sell our televisions here, because they have adopted stricter energy requirements than the EU. That is why we have to be one step ahead and do better than the legislation.*

The environmental consultant emphasises the financial crisis that forced B&O to focus on its core business and getting B&O out of the crisis as one reason for why it is a challenge to bring ecodesign to the agenda. The crisis implied, among other things, restructuring of the organisation and layoffs in many areas of the company. As mentioned in section 8.6.2, this implied that the environmental consultant had to interact with new colleagues, whom she had to educate to understand the environmental requirements and their implications for their specific work area. For example, the Marketing Department was moved to a different part of the country and a few employees were relocated as well. As a result, the new employees must, for instance, learn what the Energy Label requirements entail for the marketing of B&O's products (environmental consultant, B&O, 2012). The senior manager Product Quality Centre agrees that it has been a challenge to put ecodesign on the agenda during the financial crisis, however, from his point of view, many areas have not been prioritised in the efforts of getting B&O through the crisis, and environment has not been prioritised less than other areas. In order for product related environmental issues to become prioritised, it needs to be part of the business plan process of the Product Quality Test Centre, and B&O needs to officially decide the direction that B&O should go (senior manager Product Quality Centre, B&O, 2012).

Another explanation related to the technology is emphasised by both the senior manager Product Quality Centre and senior manager R&D (see also section 8.6.2). The senior manager R&D compares the influence of the PRS and the availability of technological solutions (senior manager R&D, B&O, 2012; author's translation):

> *Well, the PRS is describing what the product must comply with, and there are some objectives regarding what energy class we would like to comply with. And yes, we do follow that. But in reality it is more the technology roadmap of our supplier that is driving it. Because it is a matter of what we can get. As I said, we cannot influence it that much. All we can do is to push the supplier and ask them to improve this point or the energy consumption. But usually it is the other way around—we can choose the components that give the best energy consumption, and that is it.*

B&O is not able to drive the technology development, as it do not produce the technology itself and it is a small company compared to many of the other television manufacturers; this implies that the quantities that B&O purchase are merely a fraction of the production of the suppliers (senior manager R&D, B&O, 2012). As a result, the senior manager R&D is in constant dialogue with the suppliers and follows the developments in their technology roadmap closely. Furthermore, as the suppliers and their other customers are subject to the same requirements as B&O, the suppliers do have an inherent interest in improving the components. As also mentioned by the management level, the senior manager R&D stresses the fact that B&O faces bigger challenges than the competitors regarding energy requirements, due to the number of extra features of the B&O products.

In general, ecodesign is not part of everyday business in the Product Development Department nor in other departments, besides the Global Quality Department, where the environmental functions are placed. The main focus of the product development teams is producing high quality in the specified time, and in compliance with the PRS. As also mentioned in section 8.6.2, the environmental consultant tries to influence the agenda through different initiatives, such as continuous information to the product developers and management about the development, collaboration with universities on research projects and through trying to get the environment included in the business plan process (environmental consultant, B&O, 2012; senior manager Product Quality Centre, B&O, 2012). As such, the personal passion and drive of the environmental consultant is also a driver for ecodesign. As mentioned in section 8.6.2, since there is no specific company strategy to follow on ecodesign, the environmental consultant uses other instruments to generate attention to environmental issues, such as a huge poster visualising the environmental product legislations.

One exception, highlighted by the environmental consultant, is one team in the Product Develop Department in charge of screen technologies and picture quality that is paying greater attention to environmental issues than others at B&O. They do consider, also without the involvement of the environmental consultant, how to best design and construct the product to get the most energy efficient product (environmental consultant, B&O, 2012). When asked why they have this focus, the answer is that it is common, responsible behaviour, not only in society but also company-wise, *Because if we do not do something, then we risk that we cannot sell our products. So it is a very cynical approach, but of course we are all interested in saving energy. […] So it is something that interests people also personally, and therefore it is not hard to motivate people* (senior manager R&D, B&O, 2012; author's translation). It is a demotivating factor, though, that the product developers are not always able to see the logic in having energy requirements on televisions, and especially when these requirements are tightened, when other environmental impact categories, life cycle phases or even other lines of business are not regulated, although these obviously entail environmental impacts. The senior manager R&D explains (senior manager R&D, B&O, 2012; author's translation):

> *The products and televisions you can buy today in supermarkets, they cost very little. Here you actually invite people to buy the television on your way out of the supermarket, you use it and after two years you throw it out if something better comes along. This results in huge environmental impacts and is a big waste of energy, because these products must be produced and they are transported. Especially for such products that are produced where it is cheapest. […] I have at one point investigated what the environmental impact from transport from these containers is. It is mind-blowing. It is really extreme what is being transported by sea from China to Denmark.*

B&O's environmental policy does not have a direct influence on the product development process. Although it has been discussed at departmental meetings, the influence concerns behavioural issues such as turning off the light when leaving a room and turning off the coffee machine and computer rather than influence the specific product development (senior manager R&D, B&O, 2012).

According to the environmental consultant, the customers are not a driving force for improving the environmental performance of B&O's products. Neither private nor business customers, such as hotels, are, for instance, asking for ecolabelled televisions. The automotive industry has, however, been a driver for B&O implementing an environmental management system (environmental consultant, B&O, 2012).

**The Influence of the Ecodesign Directive at Bang & Olufsen's Operational Level**

As regards the specific influence of the Ecodesign Directive, the senior manager R&D emphasises that regulation along with technology development is the most important driver of the environmental performance of B&O's products. However, the Directive as such does not appear to have an effect on the ambition level of B&O: *It (the implementing measures of the Ecodesign Directive, ed.) has set some minimum requirements. We actually did have products, which had to be updated as they otherwise did not comply with the requirements. […] So it did have an influence on us, but it did not influence our ambition level* (environmental consultant, B&O, 2012; author's translation). As energy consumption is not a parameter used in the marketing of the products and is not a parameter that B&O's customers base their choice of television on, it doe not affect the ambition level besides compliance with legislation. The Energy Label could, on the other hand, influence the decision of the consumers' choice of television. Although the label has created discussions in the Product Development Department and the project teams are trying to find solutions to reduce the energy consumption of the product, if the energy consumption of the product is near a power consumption level, that would imply that the product would be awarded a better Energy Label, the Energy Labelling Directive has as such not changed the ambition level of B&O. As is the case generally regarding product-oriented environmental issues, the focus from management is missing to be able to set a standard for how ambitious B&O wants to be (environmental consultant, B&O, 2012; senior manager Product Quality Centre, B&O, 2012).

#### 9.3.2.3 Bang & Olufsen: Summary

The drivers and barriers of ecodesign in B&O are summarised in Figure 36. The green colour represents the drivers and the red colour, the barriers. (M) indicates the management level and illustrates the drivers for adopting a CSR strategy, (O) indicates the operational level and bold letters indicate the main drivers and barriers.

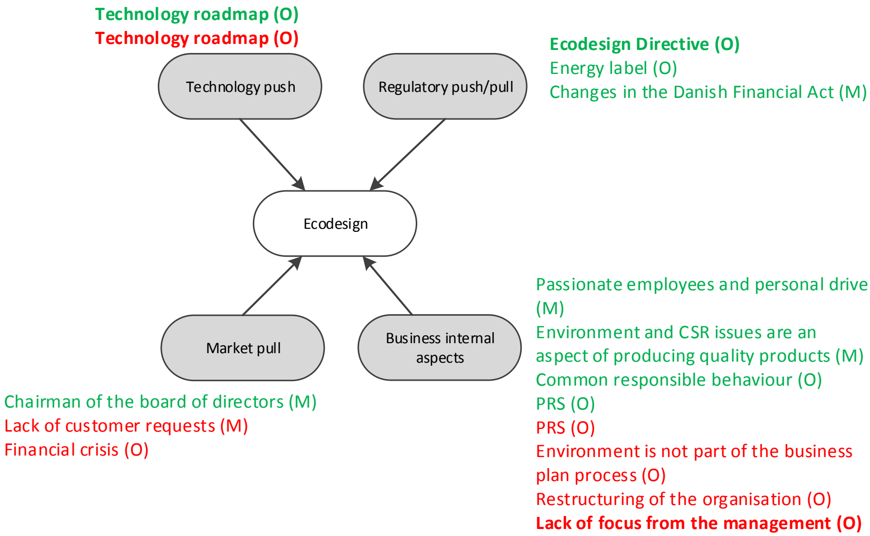


*Figure 36: Drivers (green) and barriers (red) of ecodesign in B&O.*

In summary, the management is well aware of the challenges B&O is facing in relation to complying with the requirements of the Ecodesign Directive, but the Directive as such has not influenced how a B&O product is perceived by the management. The design and the features of the products are emphasised by the management and environmental issues are perceived as an embedded aspect of quality. The drivers of the CSR strategy appear to be changes in regulation, the chairman of the Board of Directors and the understanding that working with high quality also includes working with CSR issues.

On the operational level, the technology roadmap of the suppliers has been both the main driver and barrier for the performance level of B&O's products. This is particularly due to the fact that a large part of the power consumption of the products are determined by the components delivered by the suppliers and are not possible to change. Because of B&O's quest to differentiate their products from the competitors, a number of extra features are added, and it becomes a challenge for the engineers to comply with the requirements of the Ecodesign Directive. Therefore, the technological point of departure is a main determinant for the performance of the product. The Ecodesign Directive is influential in the way that it ensures a minimum performance of the products, but is has not had an influence on the ambition level of B&O. On the operational level, a clear statement from the management is missing regarding the ambition level. Therefore, the main guide for the product developers is the PRS, which together with the technology roadmap, implies that often, merely the minimum requirements are met concerning environmental issues.

### 9.3.3. DANFOSS POWER ELECTRONICS

#### 9.3.3.1 Danfoss Power Electronics' Management Level

As highlighted in section 8.6.3 Danfoss was impacted by the financial crisis in 2008/2009, and the crisis created a barrier for prioritising environmental issues as the main focus was on getting Danfoss' back on track. Since 2012, the focus has widened a bit and it is possible to get environmental projects prioritised. According to the corporate environmental manager, the main drivers for working with environmental issues on the corporate level are a combination of Danfoss being able to see the business advantage in implementing, for example, EPDs, the customers requesting information such as EPDs, climate declarations or green passports, and that the competitors are able to provide such information (corporate environmental manager, Danfoss, 2012).

Although the customers traditionally have not requested environmental improvements beyond what is already requested by law, they do request information on the environmental impact for some of Danfoss' products, for instance, an EPD. Danfoss' company values and culture are also highlighted by the corporate environmental manager as it is an overarching foundation of Danfoss' business to behave responsibly (corporate environmental manager, Danfoss, 2012). This also includes environmental issues, though it does not imply Danfoss to be a frontrunner regarding the environment. It does, however, imply that all legislation must be complied with, and that Danfoss is following the debate in the EU and amongst competitors and customers in order to be able to respond to the trends in the debate (corporate environmental manager, Danfoss, 2012). The corporate environmental manager explains the reasons for starting the EPD project (corporate environmental manager, Danfoss, 2012; author's translation):

> *We started to see what was happening in the world, and discovered that more requirements to green product development were coming up. The customers begin to request $CO_2$ footprints and material declarations. There is a lot of hype around REACH, where we have to declare chemical*

> *content, the new RoHS recast has come, which also implies increased requirements. […] In the EU, the discussion of the raw materials initiative, and the entire discussion around rare earth metals. […] It points in the direction that it would be clever if we could present a united front instead of doing it differently in each division.*

In general, the Corporate Environmental Department has no direct collaboration with the Product Development Department in Danfoss PE and processes there. The main contact to the divisions is to the environmental coordinators, and it primarily concerns issues that are relevant for all divisions, such as reporting and legislation, for instance, the RoHS Directive and REACH Regulation. When the Corporate Environmental Department collaborates with the Product Development Department, it is through single projects, such as the EPD project. The Corporate Environmental Department has, therefore, initiated a range of different projects that are targeted product related environmental issues, and raised the general environmental awareness at Danfoss. These projects are the definition and adoption of a sustainability strategy, the development of an EPD procedure and template, and a design guide for product development (corporate environmental manager, Danfoss, 2012).

**Management Level at Danfoss Power Electronics**

At the Danfoss PE management level, it is evident that ecodesign is not high on the agenda. According to the head of PE Global Quality, the focus is specifically on the business case, which means that focus is placed on developing products with the right functionality, the right quality and at the right price. Environmental issues are not requested by the customers (head of PE Global Quality, Danfoss PE, 2012). However, in line with the corporate environmental manager, the head of Industry Affairs, is aware that customers are starting to request information about the environmental performance of the products, such as in an EPD (head of Industry Affairs, Danfoss PE, 2012).

Although it is imbedded in Danfoss' company culture to act responsibly, Danfoss PE has not taken the steps to make the environmental performance of their products into a business advantage. To the question of how Danfoss prioritises environmental issues, the head of PE Global Quality replies, *Well, it is sort of not really prioritised. It is like: 'sure we do'. But going 'all in'—that I at least haven't noticed* (head of PE Global Quality, Danfoss PE, 2012; author's translation). The head of PE Global Quality further elaborates, *My personal stand is that Danfoss could gain from nurturing a green image. I actually believe that it is possible. I am not in doubt, but we have to decide to do so* (head of PE Global Quality, Danfoss PE, 2012; author's translation). Therefore, as also mentioned in section 8.6.3, the management at the Danfoss PE level needs a clear decision and strategy from the corporate level concerning the ambitions on the environmental aspects (head of PE Global Quality, Danfoss PE, 2012; Head of Industry Affairs, Danfoss PE, 2012). The Danfoss PE management is aware that the financial crisis is one reason for this lack in focus (head of Industry Affairs, Danfoss PE, 2012). Another reason emphasised by the head of PE Global Quality is that the position towards environmental issues throughout Danfoss is that as long as Danfoss is in compliance and has the necessary certificates, everything is ‘okay’ (head of PE Global Quality, Danfoss PE, 2012). *We have a good image. We have the approvals and certificates. And with all due respect, our management in Danfoss they are really busy. […] So as long there is a green light at that KPI, then it is fine* (head of PE Global Quality, Danfoss PE, 2012).

The personal interest of the managers at the Danfoss PE level also seems to be a driver in pushing the corporate agenda. As mentioned in section 8.6.3, both the head of PE Global Quality and the head of Industry Affairs are pushing the corporate management level, as they see the future regulatory requirements and are convinced of the business opportunities that are attached to being in front of the regulation (head of PE Global Quality, Danfoss PE, 2012; head of Industry Affairs, Danfoss PE 2012). Incorporating environmental considerations in the product development processes is regarded as a natural continuation of developing a quality product, and as such, could easily be part of Danfoss’ strategic stand on product development. The head of PE Global Quality also emphasised that it could attract employees to have green image (head of PE Global Quality, Danfoss PE, 2012).

Finally, the legislation is also mentioned as a driver for improving the environmental performance of products, and it is also emphasised as a possible means to ensure that more environmental considerations are made in the product development process (head of PE Global Quality, Danfoss PE, 2012; head of Industry Affairs, Danfoss PE 2012). According to the head of Industry Affairs, the energy efficiency index classification, which is being developed on the basis of a mandate through the Ecodesign Directive, has implied that attention has been raised and focus has been directed towards where Danfoss’ products are placed on this classification (head of Industry Affairs, Danfoss PE, 2012).

#### 9.3.3.2 Danfoss Power Electronics’ Operational Level

When developing products at Danfoss, the main guide is the product requirements specification (PRS) (project manager, Danfoss PE, 2012). The main requirements in the PRS are determined by the Danfoss segment or market, i.e. a product manager, who present a product development manager with the business case, after which a product manager sets up the requirements in the PRS. Besides the requirements from the market, the PRS includes internal company requirements and regulatory requirements. According to a project manager, the drivers of ecodesign in the product development in Danfoss PE are a combination of all four categories (illustrated in Figure 37). The technological development implies higher efficiency and smaller and cheaper products, which implies that it is easier to integrate in Danfoss products. Danfoss’ company culture and values imply that it is an imbedded part of the product development process to consider different environmental issues also. It is manifested both in different company standards, e.g. in an environmental issues checklist, and in the actions of the individual product developer. *It is in the back of everybody's mind. Well, it is not something that we think about in our daily work, but we do have a standard, which tells us something about plastics and how we should be able to recycle and how we make electronics* (project manager, Danfoss PE, 2012; author's translation). The senior R&D Standardisation adds that environment, and in particular the energy aspect, is part of Danfoss' core business: *Well, environment, you see, is part of our core business. We often speak about how you can save energy. You can see that on our entire product portfolio, which to a large extent concerns solutions for energy efficiency* (senior R&D Standardisation, Danfoss PE, 2012; author's translation).

Similar to the Corporate Environmental Department, there is little interaction between the PE Global Quality Department, and the Product Development Department. The input from the PE Global Quality Department to the processes in product development is through the Danfoss standards, which the PE Global Quality Department is responsible for updating (head of PE Global Quality, Danfoss PE, 2012; environmental coordinator, Danfoss PE, 2012).

Regarding the influence of Danfoss' environmental policy on the product development processes, then the product developers trust that the aim of the policy is implemented in the Danfoss standards and the PRS (project manager, Danfoss PE, 2012). The policy does not affect the work with influencing the energy classification, described in the next paragraph (senior R&D Standardisation, Danfoss PE, 2012).

**The Influence of the Ecodesign Directive at Danfoss Power Electronics' Operational Level**

Regarding the specific influence of the Ecodesign Directive, the requirements and classification system for the energy efficiency index is still under development, while doing the interviews at Danfoss in 2012, and as such, the total influence of the Directive is not yet visible. The senior R&D Standardisation, however, expects that the first version of the classification system will not have a significant influence on Danfoss PE's products, but he underlines that analyses are on-going as to which energy efficiency classification the products will receive. The expectation is that when version two of the classification system is adopted, which implies the introduction of two extra and more energy efficient energy classes, it will impact Danfoss. At this point in time, it is to be expected that the European Commission will introduce a ban on the lowest energy efficiency classes (senior R&D Standardisation, Danfoss PE, 2012). The influence of the Ecodesign is, therefore, a reinforcement of Danfoss' strategic focus on energy efficient solutions. The senior R&D Standardisation elaborates (senior R&D Standardisation, Danfoss PE, 2012; author's translation):

> *There is no doubt that with this Directive […] focus has been significantly reinforced. Because, now it is not just something that we perhaps need to convince our customers that it is a good idea. We must expect that the customers will request it, and at the same time, we will be covered by legislation, which implies a classification in certain areas.*

The influence of the Directive is also visible in specific product development projects. For example, one project was initiated based on the knowledge of the coming energy efficiency index. The project manager explains, *It was part of the business case work that was made in the beginning. You saw the need for—that technologically we can operate with IE2, but we could see the need for being able to operate with the IE4 motors too* (project manager, Danfoss PE, 2012; author's translation).

Danfoss PE is through its business association CEMEP active in trying to influence the energy efficiency classification. Both the management, product managers and sales representatives provide input to the negotiation process about what direction Danfoss PE should lobby for. Throughout these activities, the senior R&D Standardisation continuously informs the organisation, including the Product Development Department, about the development in the standardisation work, in order for Danfoss PE to be prepared when the actual classification system is adopted (senior R&D Standardisation, Danfoss PE, 2012).

#### 9.3.3.3 Danfoss Power Electronics: Summary

The drivers and barriers of ecodesign in Danfoss PE are summarised in Figure 37. The green colour represents the drivers and the red colour, the barriers. (M) indicates the management level, (O) indicates the operational level and bold letters indicate the main drivers and barriers.

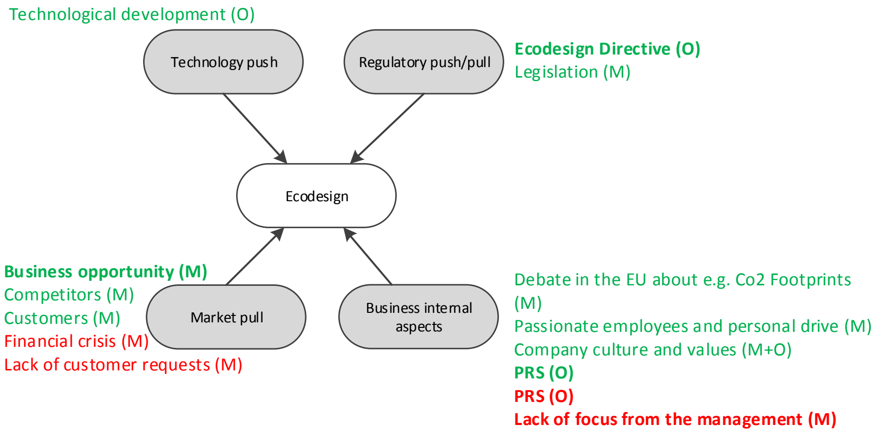


*Figure 37: Drivers (green) and barriers (red) of ecodesign in Danfoss PE.*

To summarise, on the corporate level, the attention to the product-related environmental issues is on the development and implementation of EPDs. Here the main driver is the ability to see the business opportunity of implementing them, because the customers are requesting them and the competitors are able to provide them. Another driver for starting the EPD project is the general debate and legislative initiatives in the EU. Other environmental issues including product related environmental issues have not been prioritised, and the management on the Danfoss PE level see a significant barrier in the lack of focus from the top management. The financial crisis is the main reason for this lack of focus, as well as the fact that customers are not requesting product-related environmental improvements. The passion and personal drive of single employees are a driver for ecodesign at Danfoss PE and on the corporate level.

On both the management and the operational level the company culture and values regarding responsible behaviour and conduct appear to be an imbedded part of the practices. The main guide for the product development process is the PRS, which means that the PRS is both a driver and barrier for integrating environmental considerations, as it is completely dependent on whether environmental requirements are included. Although the requirements and energy efficiency classification system of the Ecodesign Directive applicable for Danfoss' products have not been developed yet, the fact that they are being developed, and that Danfoss is following the process, implies that Danfoss is developing new products that are prepared for potential future requirements. Finally, the technological development implies that it is possible to develop cheaper products with a higher energy efficiency.

## 9.4. CONCLUSION

The aim of this chapter was to answer the research question: *What are the drivers and barriers of ecodesign in Grundfos, Bang & Olufsen and Danfoss Power Electronics and what is the influence of the Ecodesign Directive?*

The framework on determinants of eco-innovation developed by Cleff and Rennings (1999), Rennings (2000) and further developed by Rubik (2005) was used as a framework for the analysis. The framework is supplemented with the drivers and barriers of ecodesign. The drivers and barriers identified throughout the analysis, therefore, pertain to one of the four categories: technology push, market pull, regulatory push or pull and business internal aspects.

In all three companies, the main focus in all aspects of their activities is the core business, i.e. the business case. Grundfos has found a business case in producing energy efficient pumps, and to some extent, this is also the case for Danfoss PE, although this focus is not as present in their strategies and policies. At B&O, the core business is producing high-end quality products, where differentiation is a key term. Environmental issues are seen as an imbedded aspect of quality and as such there is no particular focus on environmental issues besides legal compliance. At Grundfos in particular, and to some degree in Danfoss PE, the strategic focus on energy efficiency implies that the environmental focus is limited to energy efficiency, whereas other environmental aspects are not considered. The companies' core businesses have also influenced the companies' strategy during the financial crisis. In a time of crisis, a company focus its resources on the core business. In both B&O and Danfoss it implied that little attention was given to environmental motivated projects, whereas in Grundfos, the focus on energy efficiency prevailed.

The companies' core business is also reflected in the company culture that has a significant influence on the practices in the product development. This is especially evident in Grundfos and B&O. In both companies the interviewees at the operational level emphasise that it is almost part of their upbringing in the companies to focus on energy efficiency, quality and high-end solutions, respectively, and it is connected with a great deal of pride to succeed in the endeavours to achieve these goals.

On an operational level, the PCS or the PRS is the main guide for the product developers. What is written in this specification is what is being developed. It is, therefore, an imperative that environmental requirements be written in these specifications, but it is just as important that the requirements be requested by the management in the gate reviews. Furthermore, the requirements written in the PCS or PRS have to be measurable, as the analysis of Grundfos shows that if the requirements simply state, 'focus on recycling', it is not specific enough and it can easily be overlooked. The environmental policies and strategies do not have a significant influence on the practical level of product development. Rather, they set the basis for the company culture and they must be specified in requirements in the PRS or PCS in order to directly influence the product development process.

As also highlighted in Chapter 8, the personal passion and drive of certain employees appear to be a significant driver for ecodesign. Both Grundfos and B&O collaborate with universities. In Grundfos and Danfoss, it has been possible to develop tools that should support the integration of environmental consideration in the product development process. This is the sustainability index in the case of Grundfos and the update of the design guideline in Danfoss. Furthermore, Danfoss has initiated the EPD project and Grundfos has hired a change agent within sustainable product solutions. In B&O the approach is different since no tools have been employed. Instead, the environmental consultant is working on informing the product developers about the current and coming product related environmental requirements, and is trying to incorporate environmental issues in the business plan process.

Another significant driver and barrier for ecodesign is the technological development. At B&O, the technological roadmap of the suppliers is one of the most significant determinants of the energy efficiency performance of B&O's products. B&O has been challenged by the energy efficiency requirements of the implementing measures of the Ecodesign Directive because high-end products typically include more features that require energy than the standard products. Furthermore, B&O has too little buying power to be able to drive the technological development of important components at the suppliers, and are, therefore, dependent on the progress driven by the suppliers. Grundfos, on the other hand, has been able to influence and refine the technologies used in its products as Grundfos has its own electronics factories.

Regarding the specific influence of the Ecodesign Directive, the Directive does have an influence on both the companies with a proactive approach towards energy efficiency and companies that are challenged by the requirements from the implementing measures of the Directive. However, in neither type of company does the Directive have an influence on the ambition level of the companies. The influence of the Directive on B&O, who does not have a specific environmental or energy focus in its business case, is that products have been taken out of production because they no longer complied with the requirement, and that products are being updated in order to comply. Surprisingly, the Directive has also an influence on Grundfos' products even though the entire product portfolio was in compliance with the requirements even before they came into force. Due to Grundfos' own strategy of being the best on energy efficiency, the requirements, and particularly the timeline of the requirements, push Grundfos to develop the products faster than what would have been the case without the Directive. However, the Directive is only able to push the energy efficiency agenda, as in none of the three companies, other environmental issues besides energy efficiency are being pursued.

Comparing the empirical results of this study with the findings of other authors, summarised in Figure 34, there are similarities, and all four types of determinants have been a driver and barrier for ecodesign in companies. The empirical results of this study, however, reveal that on the operational level, massive emphasis is placed on the PCS and PRS as the guide for the product development. This level of detail is not included in Figure 34. As mentioned, the analysis of the specific influence of the Ecodesign Directive reveals that the Ecodesign Directive has influenced both the companies that are in front of the legislative requirements and the companies that are challenged by the requirements. This is to some degree in contradiction to the findings of Cleff and Rennings (1999), who conclude that environmentally innovative firms are less dependent on hard state regulation, than more passive firms. However, Cleff and Rennings studies are from 1999, which means that their research was previous to the adoption of the Ecodesign Directive, and it is possible that if their research were conducted today, the findings would be different. The analysis in this study shows that the innovative firm, i.e. Grundfos, is not dependent on the Ecodesign Directive to produce products that are in compliance, but because of their own ambition level, the Directive has challenged Grundfos nonetheless. The driver has, therefore, been Grundfos' own ambitions and the possibility to use the Ecodesign Directive to increase market shares. Based on this study, it can, therefore, be concluded that the business case or the potential market advantages connected to both the voluntary and mandatory initiatives are imperative.

Reflecting upon the usefulness of the framework for analysing the drivers and barriers of ecodesign, two things deserve to be mentioned. On the one hand, the framework has functioned well in providing a structured approach to identifying the mechanisms, which the companies apply in their approach to ecodesign, and consequently, also the drivers and barriers of ecodesign in the companies. On the other hand, the framework has also been a bit rigid and the figures illustrating the findings of the analyses may not show all the nuances of the analysis. As an example, the analyses of the companies mainly focus on how the four mechanisms (regulatory push/pull, technology push, market pull and business internal aspects) are drivers or barriers of ecodesign. The illustration of the findings do not, therefore, include how any of the four mechanisms influence each other. In the case of Grundfos, its ownership of an electronics factory implies that Grundfos' internal business aspects is able to influence the technology development.

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# CHAPTER 10. PAPER: UNDERSTANDING ECODESIGN THROUGH A COMMUNITIES OF PRACTICE PERSPECTIVE

This chapter contains a paper, which has been accepted for publication in the *International Journal of Environmental Technology and Management*, and is reprinted here with kind permission from Inderscience Publishers. Inderscience retains copyright of the paper.

This paper applies Etienne Wenger's communities of practice approach to the existing environmental and product development practices of two Danish case companies. It is a contribution to the current ecodesign discussion and emphasises the social structures and practice perspectives when implementing ecodesign. The case studies reveal the importance of various social elements, which include the participatory role brokers play in organising, facilitating and negotiating meaning with different community members; the use of boundary objects for establishing dialogue and encouraging participation; and the balance between participation and reification in the process of continuously negotiating meaning. In conclusion, the ways in which ecodesign can be strengthened using Wenger's principles for cultivating communities of practice are suggested. A diversified approach to ecodesign whereby existing communities can expand their current practices and transform into ecodesign communities is also suggested. The research question that guides the analysis is:

*How are ecodesign practices strengthened by cultivating communities of practice?*

# CHAPTER 11. CONCLUSIONS PART II

This chapter contains the conclusion for Part II of this thesis, where focus was directed at three case companies covered by the Ecodesign Directive (2009/125/EC).

Even though the Ecodesign Directive provides a framework for setting comprehensive ecodesign requirements, the early adopted implementing measures especially show a unilateral focus on energy efficiency in the use phase. The case study of the implementing measure for televisions indicates a low ambition level for the minimum requirements and that the technological development has been significantly faster than anticipated in the preparatory studies. There is a tendency in the EU towards including other environmental aspects than energy, e.g. resource efficiency, which is apparent in more recently adopted implementing measures. Besides progress is also made in strengthening the interplay between the European Ecolabel and the Energy Label, but the effect of these efforts is still to be demonstrated.

The conclusions in Part I, therefore, raised the question of what is actually driving the ecodesign work in companies, and three Danish companies were selected for a case study: Grundfos, B&O and Danfoss PE. The three cases companies were selected based on their ability to be able to describe something unique, and that they were rich with information. All case companies were covered by an implementing measure directly or indirectly. Grundfos was selected as a frontrunner company, B&O was selected as a company with rather low environmental ambitions, and Danfoss PE was selected representing a company covered indirectly by being a supplier to a company directly covered by an implementing measure. The research questions to be answered in this conclusion are:

1. *How can Grundfos', Bang & Olufsen's and Danfoss Power Electronics' sustainability strategies be characterised?*
2. *What are the drivers and barriers of ecodesign in Grundfos, Bang & Olufsen and Danfoss Power Electronics and what is the influence of the Ecodesign Directive?*
3. *How can ecodesign practices be strengthened by cultivating communities of practice?*

With the first research question, the aim is to analyse the companies' overall and strategic approach to sustainability, as this is important in order to understand the context of the companies' work with ecodesign. The aim of the second research question is to analyse the ecodesign practices in more detail, and focus is on the drivers and barriers of ecodesign. The aim of the final research question is to analyse how companies can strengthen ecodesign practices through focusing on the social structures and practices in the companies.

## 11.1. SUSTAINABILITY AND COMPANY STRATEGIES

Before analysing how the case companies work with ecodesign in practice, an analysis of the companies' strategies was conducted, since strategies are the foundation of the companies' goals and activities. Attention is specifically directed towards strategies, which are determining for the companies' approach to sustainability. Within this delimitation, it is assumed that a company's approach to sustainability is an indicator of the company's ecodesign activities. The analysis includes both the deliberate strategies, which are planned and meant to happen, and they are generally monitored and controlled from start to finish, and the emergent strategies, which have no specific objective, and are a result of a consistent pattern of behaviour. The aim of this two-sided approach is to achieve a comprehensive understanding of both the written intensions as well as how they are implemented in practice.

In order to characterise the sustainability strategies of Grundfos, B&O and Danfoss PE a conceptual framework was developed. The framework identifies four levels of company strategies. On the 'ad hoc' level, the company defines its responsibilities within sustainability as merely including ensuring jobs and paying taxes, and the purpose of working with sustainability is to ensure legal compliance. Sustainability efforts are fragmented and driven by single staff members, and the company interacts with society and stakeholders on a case by case basis depending on, for example, problems arising in the factory or value chain, the communication is unilateral from company to stakeholders and communication is limited to the minimum amount determined by law.

On the second level, 'operational optimisation', the company defines its responsibilities within sustainability as protecting the environment, and the purpose of working with sustainability is to ensure that the company is continuously able to run its factories and sell its products. Sustainability efforts mostly take place in specific divisions and are not coordinated across departments and divisions, and the company systematically focuses on the interactions with stakeholders within and in close connection to the enterprise. The communication with stakeholders is two-way and the company systematically reports on sustainability-related issues.

The third level, 'organisational transformation', implies that the company defines its sustainability responsibilities with equal attention given to the triple bottom line, and the purpose of working with sustainability is to make a business case and find projects with favourable return-on-investment, and include the company's values alongside traditional return-on-investment criteria. Sustainability efforts are organised across the organisation and the company systematically focuses on the interactions with stakeholders in the entire value chain. The company's relation to stakeholders is a shared agenda with focus on creating win-win situations, and the company's approach to transparency is full disclosure of goals and results.

The fourth level of sustainability strategies is 'systems building', where the company defines its responsibilities within sustainability as making changes in society through the use of its business models, and sustainability is therefore an intrinsic part of the company's business model. Sustainability is part of business, all lines of business are engaged, and the company interacts systematically with stakeholders in the entire society. The company's relations to stakeholders is that they work together on important issues as equal partners, and transparency is ensured through third party verification of the reported results.

The framework functioned as a guiding point when making the interview guides and as a search tool in the analysis of both documents and interviews, and it enabled a visual presentation of the findings. The analysis of the company strategies was two-sided in that information was first obtained through written, public material, such as annual reports and sustainability reports, and subsequently, key persons were interviewed about how the strategies are implemented in practice. This duality corresponds to Mintzberg's definition of a strategy including both deliberate strategies, e.g. plans and written strategies, and emergent strategies, e.g. the patterns of behaviour.

### 11.1.1. CHARACTERISATION OF THE STRATEGIES RELATED TO SUSTAINABILITY

Grundfos works with sustainability primarily on an organisational transformation and systems building level. This implies, among other things, a high ambition level; that Grundfos works with sustainability in its entire value chain; and that Grundfos also engages in partnerships with other organisations outside the value chain; and is engaged in creating new business opportunities and markets. The high ambition level is not, however, completely integrated in the company structure, and also, the implementation of the strategic intent is at an ad hoc level. Furthermore, the primary focus of Grundfos concerning ecodesign, so far, is energy efficiency, but Grundfos is developing a tool (the sustainability index), which aims at integrating other sustainability aspects, such as materials and recycling, and society impacts in the product development process.

Both B&O's and Danfoss PE's sustainability strategies are primarily focused on operational optimisation, including elements of both organisational transformation and ad hoc strategies. This implies that to some degree, they do include sustainability in their strategies, but that significant efforts are necessary in order to completely integrate sustainability into the daily practices around product development. In the case of B&O, environmental aspects, i.e. ecodesign, are considered to be an imbedded part of quality, and as such, do not receive specific attention.

B&O has initiated a process of developing a CSR strategy, but acknowledged that it is a journey that has just begun, and that it may take some time before the strategy is developed and completely integrated in the business. However, considering B&O's priorities so far—which are high-end quality, design and differentiation, the fact that B&O is dependent on the technological development, and that B&O does not consider the environment an issue, which differentiates B&O's products from others—it is questionable how much the CSR strategy will change the ambition level concerning being proactive on environmental aspects.

At the corporate level in Danfoss, work has also been initiated on a sustainability strategy, and on updating some design guides for the product development process. However, this work has not yet been diffused to the division levels, and Danfoss PE is missing a clear statement from the corporate management on the direction Danfoss want to go concerning sustainability. Danfoss declares itself as 'fast followers' and not as 'frontrunners'.

Interestingly, even though the three companies have different strategies towards sustainability, the employees face similar challenges when aiming to work more with sustainability. As already mentioned in the case of Grundfos, the organisational structure is not yet in line with the ambition level, and this applies to B&O and Danfoss PE as well. The product development and the environmental support functions are separate entities and there is limited interaction, and the initiatives to integrate environmental issues in the product development projects are often met with scepticism. Furthermore, single staff members are drivers for working with sustainability in all three companies.

## 11.2. DRIVERS AND BARRIERS OF ECODESIGN

In the second part of the analysis of the case companies, attention was directed towards the actual practices of the companies focused on identifying the drivers and barriers for working with ecodesign in the three companies. The analyses were divided in two parts: the management level and the operational level. This distinction was made because the analyses of the company strategies revealed that the ambitions of the strategy documents and policies were not necessarily reflected in the actions and actual practices on the operational level. The analysis was, therefore, aimed at analysing the drivers and barriers of ecodesign on the management level, including the strategy and policy documents, and on analysing the drivers and barriers of ecodesign on the operational level, i.e. the actual practices.

The analysis was guided by a framework originally describing the determinants of eco-innovation, but in the chapter, it was argued that eco-innovation and ecodesign to a large extent are comparable, and as such, the framework can be applied to ecodesign as well. The framework identified four main determinants of ecodesign. The first determinant, regulation, can create a push through, for example, command-and-control like requirements, such as the minimum requirements in the Ecodesign Directive or the RoHS Directive, or it can create a pull by incentivising the companies, for instance, through the Energy label. Technology push is the second determinant of ecodesign, and technology can be a driver or barrier for ecodesign through, for example, the availability of new technologies that improve the environmental performance of the product; this could be within, for example, material or energy efficiency. The third determinant is market pull, which is when customers demand environmentally-friendly products or prefer companies with a green or sustainable image. Competition and the potential for creating new markets or increasing market share are also part of the market pull drivers. Finally, business internal aspects are a determinant of ecodesign. Business internal aspects are, for instance, the size of the company, the strategies of the company and how the environmental work is organised in the company.

The analysis of the three case companies reveals that the companies' business strategy is a crucial driver of any activities at the companies. As such, they can also be a major both driver and barrier for practicing ecodesign in the companies. For example, as highlighted in Chapter 7, at Grundfos, where energy efficiency is a high priority and a business case. This is, to some degree, also present in Danfoss PE, whereas in B&O, the focus is on high-end quality products and design, and the lack of focus from management on environmental issues is a main barrier for ecodesign. The companies' core business focus is reflected in the company culture as well. This is evident from statements of interviewed employees at all three companies, as the product developers almost automatically aim to optimise energy efficiency and quality issues at Grundfos and Danfoss PE, and quality at B&O.

At the operational level in the product development, the product concept specification and the product requirement specification are the main guides for the product development. All types of requirements for the product, including regulative and internal company requirements, should be listed here in order for the product development teams to consider them. Another major driver and barrier, especially regarding energy efficiency, is the technological development. Due to the extra functionalities, which high-end products include, B&O is particularly dependent on the technology to be able to achieve higher energy efficiency. At both Grundfos and Danfoss PE, the technological shift to the permanent magnet motor technology has resulted in the possibility of achieving high energy efficiency.

Regarding the specific influence of the Ecodesign Directive, it is interesting that the Directive influences the companies no matter at what strategy level they are working with sustainability. At B&O, who does not have a specific environmental or energy focus, the influence of the Directive is that products have been taken out of production because they no longer complied with the requirement, and that products are being updated in order to comply. At the frontrunner company, Grundfos, the Directive also has an influence even though the entire product portfolio was in compliance with the requirements even before they came into force. Due to Grundfos' own strategy of being best on energy efficiency, the requirements and particularly the timeline of the requirements push Grundfos to develop the products faster than what would have been the case without the Directive. In neither of the companies, though, does the Directive have an influence on the ambition level of the companies. This implies that the Directive is merely able to remove the worst performing products from the market and possibly drive the development faster than without the Directive, but is not able to drive a company agenda, unless the Directive more clearly demonstrates the business case in complying with its implementing measures. Furthermore, the unilateral focus of the Directive is also visible at the companies, in that all three companies work with energy efficiency, whereas other environmental issues are lacking behind. Grundfos is implementing the sustainability index and Danfoss is developing EPD and updating design guides.

## 11.3. BROKERING SOCIAL STRUCTURES IN ECODESIGN THROUGH COMMUNITIES OF PRACTICE

The third research question was initiated from an inquiry as to why ecodesign is not more widely practiced in companies in spite of many years of tool development and legislative initiatives. Focus was directed at the ecodesign practices in companies and how these can be strengthened through a community of practice perspective. With this paper, the aim was to take the analysis of the case companies one step further and find solutions to how companies' ecodesign efforts can be improved. The analysis used examples from two cases studies, B&O and an anonymous company, and Etienne Wenger's theory on communities of practice was applied as a framework for understanding the examples.

The paper concluded that both case companies have a mature product development community and that the practices are highly reified through the product development process and the product requirement specification, both representing boundary objects. However, in both companies, this mature community of practice does not effectively engage with the environmental function of the company. Instead, the environmental specialists act as brokers in the periphery of the community and are by the community considered as support functions that can be contacted if needed. On this basis, it is a challenge for the environmental specialists to introduce ecodesign concepts and practices.

The paper included three examples from the case companies, which illustrated the importance and difficulties of the different elements of communities of practice. In the first example from company 1, the importance of brokers are illustrated in that an environmental specialist was hired particularly with the aim of focusing on product-oriented environmental protection, and specifically incorporating the corporate standards for product-oriented environmental protection in the product development processes. Despite the existence of corporate standards, the environmental activities at company 1 remained production-oriented until the environmental specialist was hired. The success of the environmental specialist in incorporating the standards in the product development processes are due to the environmental specialist's ability to act as a broker between both corporate standards and the product development community, through, among other things, being able to translate the environmental requirements from the standards and creating new boundary objects and using them to engage the product development community.

The second example concerns company 2 and focuses on the importance of boundary objects as translation tools for promoting learning and creating awareness and improving the environmental performance of products. In company 2, environmental requirements were solely integrated in the product requirements specification, which proved to be a challenge for a number of reasons including the fact that the legislative requirements in the product requirement specification are minimum requirements and as such, do not encourage a high environmental ambition level. This way of setting environmental requirements does not illustrate a shared repertoire on ecodesign or create an active involvement from the product development team. Rather, these requirements were seen as design constraints and extra work for the product development team. In response to these challenges, the environmental specialist, therefore, developed a visual tool, internally referred to as the 'cry-wall', which helps communicate the various legislative demands, reduce the complexity of the requirements and thereby raise awareness especially among management and engineers. The strength of the 'cry-wall' is the visual representation, but without it being used more actively in the product development processes, the ecodesign activities will remain at the periphery of the product development community. The final example of the discontinuation of the dismantling tests in company 2, furthermore, illustrates that a balance between reification and participation is important for a successful community.

The paper concluded that it is possible to cultivate communities of practice, and through these communities, to strengthen ecodesign in companies. It was proposed to take a diversified approach to ecodesign, where different communities and not only the product development team are encouraged to adopt a shared environmental concern for the products' impacts and increase their knowledge and practice concerning how to contribute to ecodesign solutions. More specifically, the recommendations took their point of departure in Wenger's seven principles for cultivating communities of practice. The first principle prescribed that communities of practice should be designed to encourage natural development. One way of ensuring this is linked to the fifth principle, which prescribes that it is important to make the value of participating in the community clear, in which case the engineers will voluntarily participate in the community. The second principle prescribes that the community should invite perspectives from both inside and outside the community, for instance, as in the case of company 1, where the environmental specialist engages with the product development community in the co-development of the ecodesign targets. The third principle concerns the openness of the community for participation of both core and peripheral members of the community, and the fourth principle states that room should be established to facilitate both activities with many participants and one-on-one exchanges. Furthermore, it is important when cultivating communities of practice to create familiarity in the community practices to ensure a sense of belonging, but a sense of excitement is also necessary to keep the interest of the community members, which is the sixth principle. The seventh principle states that rhythm of a community is important to ensure the 'aliveness' of the community. The final two principles are illustrated well in the third example given in the paper about the dismantling event. The former dismantling event was perceived as an exciting event, which complimented the routine way of developing products, and they were held on an iterative basis following the new products being developed. When the dismantling events were discontinued, both the rhythm and the organisational learning around ecodesign ceased with it.

Comparing the findings of the paper with the findings of the analyses of the company strategies and drivers and barriers of ecodesign, examples can be found of the importance of the role of the brokers in the bridge-building between different communities. One example is that the product development and the environmental support functions are separate entities. In this case, a broker could facilitate and encourage the communities to adopt a shared concern of the products' environmental impact. The fact, as emphasised in both Chapters 8 and 9 that single staff members are significant drivers of ecodesign, is an example of such brokering activities, although the example also illustrates that brokers cannot stand alone. Boundary objects are also important in the process of negotiating meaning and establishing a shared practice. At best, ecodesign practices are strengthened when there is a balance between participation and reified items. Examples of reified items and boundary objects from all three case companies are the many strategy documents, policies and tools, including issues on sustainability.

An essential point to notice from Chapters 8 and 9 is that where both Grundfos and Danfoss have a large number of strategy documents, policies and tools which in some include sustainability issues, B&O has less of these more formal boundary objects. Instead, the brokering activities of the environmental specialist and her ability to create boundary objects, e.g. the 'cry wall', become significant.

The first step in cultivating communities of practice is, however, that a decision is made that they must be cultivated. Although, the example in the paper on, for instance, the 'cry wall' visualising the environmental legislation, showed that single initiatives by single staff members can influence the immediate product development.

The analyses in Chapters 8 and 9 showed that support and direction from the management is imperative for a successful ecodesign implementation. The fifth principle for cultivating communities of practice, concerning that it is important that the value of participating in a community should be visible in order for it to succeed, as participation often is voluntary, was also supported by the findings in Chapters 8 and 9. In order for ecodesign to reach the agenda of the management, it is necessary that ecodesign create a business case in the companies, as this is the main driver for any agenda at the companies.

## 11.4. REFLECTIONS

In conclusion, reflections is made on the decisions made throughout the research process and their consequences.

The first reflection concerns the selection of the three case companies and how well the case companies fit the selection criteria. The selection criteria were that:

- The companies should be covered by an implementing measure
- Grundfos was selected representing a frontrunner company
- B&O was selected representing a company with rather low environmental ambition
- Danfoss PE was selected representing a company, which was covered indirectly by being a supplier of a company directly covered by an implementing measure

All three case companies are in accordance with the first selection criteria, in that all were covered by an implementing measure. The analyses of Grundfos revealed that Grundfos indeed was a frontrunner company in terms of energy efficient solutions. This was a focus point for Grundfos since the beginning of the company, and they were also successful in influencing the legislative process on the Energy Label and are currently active in their business association in relation to the implementing measures of the Ecodesign Directive. However, the analysis also revealed that Grundfos had a rather unilateral focus on energy aspects, and therefore, their frontrunner status was limited to this specific focus. This was particularly visible in the way the environmental activities were structured, and through the fact that the influence of single staff members was important when other environmental aspects were considered.

As regards B&O, the analysis supported the initial selection criteria concerning B&O having a rather low environmental ambition level. This was visible, among other things, in the number of strategy documents, which included sustainability, in its perception that environmental issues did not differentiate B&O’s products and in the fact that the Department for Safety, Health and Environment was closed and the functions spread to other departments. However, B&O did have a systematic approach, which ensures that the legislative and internal environmental criteria were met, and therefore, B&O could not be classified as a critical case of an unambitious company.

Finally, the analysis of Danfoss PE revealed that Danfoss PE was covered indirectly by implementing measures through being a supplier. However, since Danfoss PE did not experience any demands from its customers regarding requirements in the implementing measures, and since Danfoss PE itself was directly covered by implementing measures, all activities at Danfoss PE regarding implementing measures was initiated by the company itself. Therefore the analysis did not reflect the supplier angle properly as originally intended, but it represented an extra angle to the analyses of companies covered directly by implementing measures.

Concerning the distinction of the interviewees on a management and operational level, in Part II of the thesis, it proved more difficult in practice than anticipated. In the case of Grundfos, besides one director, it was not possible to conduct interviews at the top management level. This implied that the analysis in Chapter 8 concerning the sustainability strategies to a large extent was based on the written strategy documents in the case of Grundfos, as opposed to the analysis of B&O and Danfoss PE, where interviews with the management level were possible. In the case of B&O, the circumstances were opposite to those in Grundfos in the sense that it was deliberately chosen to mainly interview persons on the management level, due to my understanding and knowledge of B&O on the operational level. Although the aim was to enter the interviews with an open and objective mind, the insider knowledge I had on, for example, how environmental issues are considered in the product development process was known beforehand, may have unintentionally led the interviews and discussions in a certain direction.

A final reflection is made on the analyses in Chapter 8 concerning the company strategies, which were based on both document analysis and interviews. Both methods were applied in order to analyse both the deliberate and emergent strategies, but the issue was how much weight should be placed on the written documents compared to the statements from the interviews. When inconsistency was detected between the documents and the interview statement, this was interpreted as differing deliberate and emergent strategies, and both were plotted in the conceptual framework. In the analysis, B&O and Danfoss were characterised fairly equally; however, solely analysing the documents would reveal a higher ambition level for Danfoss than B&O. It is the rather critical statements at Danfoss, which causes the characterisation of Danfoss PE to be at the same level as B&O. In retrospect, it could be questioned whether the rather critical comments towards a fairly high ambition level at Danfoss equals a lower ambition level, but fewer critical comments at B&O. However, since all analyses were sent to the companies for validation, the analysis in Chapter 8 does reveal an accurate picture of the companies.

# APPENDICES

# Appendix A. List of Interviewees and Interview Guide

This appendix provides the details about the interviews conducted for the PhD thesis and the interview guides. In Table A-1, the interview details on the interviews conducted for Part II of the thesis are presented.

*Table A-1: Overview of the interviews conducted for this PhD thesis.*

| | **Management level** | | | **Operational level** | | |
|---|---|---|---|---|---|---|
| **Grundfos** | Sustainability consultant | Eva Lauersen | 10.05.2012 | Product development manager | Mogens Meyer | 12.04.2012<br>02.05.2012<br>22.01.2013 |
| | Chief engineer | Niels Bidstrup | 08.06.2012 | Senior project manager | Frank S. Madsen | 12.04.2012 |
| | Project manager of the Sustainability Index | Patrick Berceville | 25.06.2012 | Product development manager | Jørgen Vest Sørensen | 02.05.2012 |
| | Technology director | Henrik Ørskov | 02.07.2012 | Global programme manager | Troels Sørensen | 02.05.2012 |
| | | | | Global programme manager | Steen Tøffner | 02.05.2012 |
| | | | | D&E global support manager | Andreas Bach Petersen | 10.05.2012 |

<table>
<tr><td rowspan="4"></td><td></td><td></td><td></td><td>Environ-ment engineer</td><td>Louise Bisgaard</td><td>10.05. 2012</td></tr>
<tr><td></td><td></td><td></td><td>Chief NDI</td><td>Carsten Petersen</td><td>10.05. 2012</td></tr>
<tr><td></td><td></td><td></td><td>Chief product engineer</td><td>Carl Christian Danielsen</td><td>08.06. 2012</td></tr>
<tr><td></td><td></td><td></td><td>Change agent</td><td>Anna Pattis</td><td>22.01. 2013</td></tr>
<tr><td rowspan="5">Bang & Olufsen</td><td>Director Global Quality</td><td>Martin Wingaa</td><td>23.11. 2012</td><td>Environ-mental consultant</td><td>Lone Nielsen</td><td>17.08. 2012<br><br>07.04. 2014</td></tr>
<tr><td>Senior manager Product Quality Centre</td><td>Jesper Gregersen</td><td>23.11. 2012</td><td>Senior manager R&D</td><td>Ben Leonar-dous Verbraak</td><td>23.11. 2012</td></tr>
<tr><td>Senior director Idea Factory</td><td>Flemming Møller</td><td>23.11. 2012</td><td>Product environ-mental consultant</td><td>Britt Gamskjær Vroue</td><td>31.01. 2014</td></tr>
<tr><td>Environ-mental manager</td><td>Rikke Dencher Aagaard</td><td>08.02. 2013</td><td></td><td></td><td></td></tr>
<tr><td>Senior technolo-gy specialist</td><td>Søren Bech</td><td>23.11. 2012</td><td></td><td></td><td></td></tr>
</table>

| | | | | | | |
|---|---|---|---|---|---|---|
| Danfoss Power Electronics | Head of Industry Affair (PE) | Bruno Lund Pedersen | 01.11. 2012 | Global business director, Pump OEM | Frank Taaning-Grund-holm | 23.08. 2012 01.11. 2012 |
| | Corporate environ-mental manager | Flemming Lynge Nielsen | 29.11. 2012 | Environ-mental coordinator (PE) | Pia Lund Brodersen | 29.11. 2012 |
| | Head of PE Global Quality | Dan Øster-gaard | 29.11. 2012 | Director for Marketing Services (PE) | Susanne Stefanie Krag | 29.11. 2012 |
| | | | | Senior R&D Standardisa -tion (PE) | Preben Holm | 29.11. 2012 |
| | | | | Project manager (PE) | Lone Harvest | 29.11. 2012 |

For all interviews, an interview guide was prepared beforehand. Point of departure for all interviews was the same interview guide, but it was adjusted to the three different case companies, and according to the interviewees' position in the company. In Table A-2, an example of an interview guide is illustrated.

*Table A-2: Example of interview guide for Grundfos on the management level.*

| |
|---|
| **Introduktion** |
| Navn<br>Stilling<br>Ansat hvor længe<br>Primære arbejdsopgaver |
| **Miljøpolitik** |
| Jeg har læst på jeres hjemmeside og har ikke fundet en miljøpolitik. Har I en decideret miljøpolitik?<br>(Hvad sender I til jeres kunder hvis de spørger efter en miljøpolitik?) |

| |
|---|
| Eller er det Grundsfos' værdiggrundlag, som udgør miljøpolitikken? (6 værdier, be, think, innovate |
| Hvorfor har I (ikke) en miljøpolitik? |
| Inkluderer jeres miljøpolitik produktmiljø? (researches inden interview) |
| Hvem har været involveret i tilblivelsen af jeres miljøpolitik? |
| Hvordan er I kommet frem til indholdet i jeres miljøpolitik? |
| Hvad har haft en indflydelse på indholdet i jeres miljøpolitik? |
| **Grundfos, White paper. Our perspective on the climate challenge – sustainability first** |
| Hvorfor har Grundfos dette white paper? |
| Hvem igangsatte arbejdet omkring white paperet? |
| Hvem internt I organisationen har været involveret I tilblivelsen af Grundfos' white paper? |
| Hvilke eksterne aktører har været involveret I tilblivelsen af Grundfos' White paper? |
| Hvordan er I kommet frem til indholdet i Grundfos' white paper? |
| Under forpligtigelsen til at påvirke den globale agenda star der at (p.21): *We will increasingly seek to influence legislators across the world…*<br>Hvad vil I opnå med det??<br>Hvordan vil I gøre det? |
| **Innovation Intent** |
| Hvorfor har Grundfos et "innovation Intent"? |
| Hvem igangsatte at der blev udarbejdet et innovation intent? |
| Hvem internt I organisationen har været involveret I tilblivelsen af Grundfos' innovation intent? |

| |
|---|
| Hvilke eksterne aktører har været involveret I tilblivelsen af Grundfos' innovation intent? |
| Hvordan er I kommet frem til indholdet i Grundfos' innovation intent? |
| **Product Categorisation** |
| Hvorfor har Grundfos 'Product categorisation'? |
| Hvad er formålet projektet? |
| Hvem igangsatte projektet? |
| **Virksomhedens strategiske satsning** |
| Hvad har været afgørende for jeres ambitionsniveau på produktmiljøområdet? |
| Hvilke drivkræfter ser du for at have en bæredygtighedsstrategi? (el. miljø) |
| Hvilke barrierer ser du for at have en bæredygtighedsstrategi? (el. miljø?) |
| **Determinants of eco-innovation** |
| Hvilke interne og eksterne aktører har påvirket jeres ambitioner omkring forbedring af miljøbelastningen fra jeres produkter? |
| Ifølge en teori, som jeg arbejder med i mit projekt, så er der fire elementer, som påvirker en grøn produktudvikling:<br>- Teknologiudviklingen, produktkvalitet, energieffektivitet, materialeeffektivitet<br>- Markedet, eks. kunders efterspørgsel og konkurrenters aktiviteter<br>- Regulering, eks. dansk og EU lovgivning<br>- Interne virksomhedsaspekter, eks. virksomhedens størrelse, interne politikker<br><br>Kan du forklare hvordan dette billede ser ud for Grundfos (specielt for din pumpe)? Hvad har konkret haft en indflydelse på jeres ambitioner på miljøområdet og hvordan? – Skriv på tegningen |
| Hvilke aktører har påvirket jeres ambitioner omkring forbedring af miljøbelastningen fra jeres produkter? |
| Hvilken miljølovgivning har haft en indflydelse på jeres ambitioner på miljøområdet? |

| **Ecodesign direktivets indflydelse** |
|---|
| Kender du Ecodesign direktivet? |
| Hvordan blev du gjort bekendt med direktivet? |
| Hvem er ansvarlig for overholdelse af direktivet hos jer? |
| Hvilken indflydelse har direktivet haft for jeres ambitioner på miljøområdet? |
| Holdes du opdateret på udviklingen ift. opfyldelse af direktivets krav? |
| Hvordan holdes du opdateret på udviklingen ift. af direktivets krav? |

# Appendix B. Report: Ecodesign Requirements for Televisions

This appendix contains a report published by the Danish Environmental Protection Agency in 2012. The report is reprinted here from: http://mst.dk/service/publikationer/publikationsarkiv/2012/nov/eco-design-requirements-for-televisions/.

The focus of this report is the implementation of the EU Directive 2005/32/EC on ecodesign requirements for energy-using products (the EuP Directive) with special attention to the ecodesign requirements for televisions. The aim is to investigate the scope of the implementing measures, how ambitious the requirements of the implementing measures are, and to what degree they can promote eco-innovations of televisions.

It is concluded that the potential of the EuP Directive has not been fully realized, since only requirements related to energy efficiency in the use phase have been set up, while other improvement potentials based on an ecodesign rationale have been neglected.

Danish Ministry of the Environment

# Eco-design Requirements for Televisions

## How Ambitious is the Implementation of the Energy-using Product Directive?

Miljøprojekt nr. 1450, 2012

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**Editing:**

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However, publication does indicate that, in the opinion of the Danish Environmental Protection Agency, the content represents an important contribution to the debate surrounding Danish environmental policy.

# Contents

# Preface

Today, electronic products are everywhere in our households. The quantity is increasing; and it is common to have a TV not only in the living room, but also in the bedroom, the kitchen and even in the children's rooms. According to the Danish Energy Agency the number of TVs in Danish households has grown from around 2.2 million in 1980 to around 5.5 million in 2010 (Danish Energy Agency, 2012). That equals a growth from approximately 1 TV per household to around one per person. Also the variety of products is increasing: families have TV, DVD player, Xbox, Play Station or Wii, PC, laptop, fixed line phone, several mobile phones and the list could go on. With this amount of products the environmental impact of a household cannot be traced back to a few major contributors, but is shared by many products.

The products are at the same time getting more complex both in terms of their functions and the components inside the product, but also in terms of their product chain and the stakeholders involved during the product lifetime. A product might be sold in Denmark, but it is produced in South Korea with suppliers and subsuppliers from China, Malaysia and Singapore delivering parts to the final product. Once the product is broken or the consumer simply finds it out of fashion it is thrown out – hopefully in a way so it can be disassembled, materials reused and toxic substances handled properly. Unfortunately, loads of old ICT equipment end up in scrap yards in India or Africa, where they are disassembled in a way being a danger both to the environment and the health of people.

This development has challenged the approach to regulate and stimulate the innovation of cleaner products. EU has introduced the Integrated Product Policy (IPP) in 2003. IPP is based on some key principles, first of all the life cycle perspective that means considering the environmental impacts of the entire product life cycle from the extraction of raw materials, production, transport, use, recycling and disposal. IPP is an integrated approach aiming at promoting measures to reduce the environmental impact of products at a point where this is most effective (European Commission, 2003a). Several policy instruments have been introduced such as new directives that partly aim at ecodesign, and other instruments such as energy- and eco-labelling has been expanded to include electronics.

Several people have provided valuable insight to this report, and especially warm thanks to: Gert S. Hansen, Danish Environmental Protection Agency; Peter Nielsen, Danish Energy Agency; the former chair for the Electronic Product Panel, Jesper Thestrup; Carla Smink, Aalborg University; that commented thouroughly on earlier drafts of the report. The full responsibility is still with the authors.

Rikke Dorothea Huulgaard & Arne Remmen, Aalborg University, 2012.

# List of Abbreviations

| | |
|---|---|
| BAT | Best Available Technology |
| EEI | Energy Efficiency Index |
| EIC | International Electrotechnical Commission |
| EuP Directive | Energy using products Directive |
| IM | Implementing Measure |
| IPP | Integrated Product Policy |
| PBB | Poly-brominated biphenyls, a substance restricted in the RoHS Directive |
| PBDE | Poly-brominated dephenyl ethers, a substance restricted in the RoHS Dierctive |
| RoHS Directive | Restriction of Hazardouos Substances Directive |
| WEEE Directive | Waste Electrical and Electronic Equipment Directive |

**Television Technologies:**

| | |
|---|---|
| CCFL | Cold Cathode Flourescent lamps. Technology used as backlight in LCD screens |
| CRT | Cathode Ray Tube. Technology which uses heat to create light by stricking large numbers of electrons against glass. The glass is leaded to block for X-rays generated by the high energy electrons inside the CRT. (Stobbe 2007e) The CRT technology is succeeded by the flat panel displays. |
| FDP | Flat Panel Display. PDP and LCD are both FDP technologies |
| HCFL | Hot Cathode Flourescent Lamp. Backlight technology used in LCD screens which have considerable benefits in terms of reduced energy consumption |
| HD | High definition. Refers to the resolution of the TV. A HD TV has a significant higher resolution than standard Tvs. |
| LCD | Liquid Crystial Display. Technology which uses a backlight as light source, such as CCFL or LED. LCD screens consist of a number of pixels which consist of liquid crystals that can alter their crystalline structure or orientation when voltage is applied. (Stobbe 2007e) |
| LED | Light Emitting Diode. Backlight technology used in LCD screens. Some of the advantages of LED are a thinner panel, lower power consumption, better heat dissipation, a brighter display, and better contrast levels. |
| OLED | Organic Light Emitting Diode. Technology which consists of organic materials i.e. layers of plastic. When currents run through an OLED display, each OLED emits light on its own, without the need of a backlight system. (Bush 2009) The advantages of OLED displays are a reduced energy and materials consumption compared to typical LCD screens due to a thinner panel and a deep black level. (Freudenrich 2005) |

| | |
|---|---|
| PDP | Plasma Panel Display. Self-emissive flat panel technology which creates light in a cell byosphors excited by a plasma discharge between two flat panels of glass. Each cell is filled with a gas and sandwiched between layers of electrodes. A voltage of 100 to 200V is required to ignite the plasma for individual pixels, and display heating as well as radio frequency emission has to be carefully controlled. The first generations of plasma sceens contained lead but by 2006 lead free plasma screen are available. (Stobbe 2007e) |
| RP | Rear Projection. RP is a common denominator for technologies where a projector or light source casts the image on the rear of the screen. |
| TFT | Thin Film Transistor. This technology on glass is used to drive or control the orientation of the liquid crystals (pixels) in and LCD screen. |

# Sammenfatning og konklusioner

Denne rapport omhandler implementeringen af EU Direktiv 2005/323/EF om rammerne om fastlæggelse af krav til miljøvenligt design af energiforbrugende produkter (EuP Direktivet), med særlig vægt på miljøkravene til fjernsyn. Målet er at undersøge gennemførelsesforanstaltningernes rækkevidde, hvor ambitiøse gennemførelsesforanstaltningerne (IM) er og i hvilken grad de vil promovere miljøvenlig innovation. I det følgende er rapportens hovedkonklusioner markeret med fede typer.

Rapporten består af fem dele:

- Definitionen af ecodesign
- EuP processen: fra forstudierne til gennemførelsesforanstaltningerne
- Forholdet mellem gennemførelsesforanstaltningerne og forskellige energi- og miljømærker
- Nye markeds- og teknologitrends sammenlignes med kravene i gennemførelsesforanstaltningerne og miljømærkerne.
- Analyse af den Europæiske energimærkningsordning for TV

I første del af rapporten defineres ecodesign som et koncept, der inkluderer alle miljøaspekter i hele et produkts livscyklus. EU har reageret på denne tilgang gennem integreret produkt politik (IPP). IPP inkluderer både frivillige og påkrævede instrumenter med det formål enten at sætte minimumskrav eller at skabe incitamenter for frontløber virksomheder til at forbedre deres produkter endnu mere.

I anden del af rapporten sammenlignes de anbefalede krav i forstudierne med kravene fra IM. Forstudierne, udarbejdet af et konsortium bestående fem partnere, ser bredt på et fjernsyns miljøpåvirkninger, dog bliver det kraftigt fremhævet, at energiforbruget i brugsfasen har den største miljøpåvirkning. **Gennemførelsesforanstaltningerne har derimod et snævert fokus på fjernsynets energiforbrug i standby, slukket og tændt tilstand.** I IM er anbefalingerne fra forstudierne blevet fulgt på standby, mens kravene til tændt tilstand er skærpet og kravene i slukket tilstand er slækket. Der bliver i IM ikke stillet krav til kemikalier og genbrug, men der henvises til kravene i RoHS og WEEE Direktiverne.

Arbejdet med forstudierne begyndte i 2005 og den endelige rapport blev fremlagt i 2007. IM blev vedtaget af Kommissionen som Forordning i juli 2009, og fjernsyn skal opfylde til de første krav i januar og august 2010. En proces på fire år til ikrafttrædelse af krav stiller udfordringer til forstudierne og IM om at være fremsynede og inkludere ny teknologi. Forstudierne har i vis grad inkluderet overvejelser om nye teknologier. Nogle forældede teknologier er ikke blevet medtaget i undersøgelserne, eksempelvis CRT, mens der blev fokuseret på teknologier, der af konsortiet bag forstudierne blev vurderet til at være førende på markedet, nemlig LCD og Plasma.
**Gennemførelsesforanstaltningerne har dog ikke været i stand til at inkludere nyudviklede teknologier**, som har en interessant miljømæssig profil. For eksempel er fjernsyn baseret på LED teknologi betydeligt mere energieffektive end kravene i IM (se figur 5-1 & 5-2), og på samme tid eliminerer teknologien

brugen af kviksølv. Denne teknologi blev for alvor introduceret på markedet i 2009, men har dog ikke haft indflydelse på minimumskravene i IM.

I tredje del af rapporten er ambitionsniveauet i EuP direktivet undersøgt ved at sammenligne de fire miljømærker (EU Blomsten, der Nordiske Svanemærke, Energy Star og TCO´06) med IM. Hovedkonklusionerne er, at IM har et smalt fokus på energiforbrug, mens de fleste miljømærker ser bredere på produktets miljøpåvirkning. **Som forventet stiller gennemførelsesforanstaltningerne lavere krav end alle miljømærkerne**, med undtagelse af til standbyforbruget, som svarer nogenlunde overens med miljømærkernes krav. Indholdet af kviksølv og flammehæmmere, forlængelse af levetid samt demonteringsdesign er eksempler på områder, som der stilles krav til i miljømærkerne, men som ikke berøres af IM.

Tabel 1 Forstudiernes, IM og miljømærkernes fokusområder. Den grønne farve illustrerer det primære fokus, mens den gule farve illustrerer det sekundære fokus.

| | Forstudierne | IM | EU Blomsten | Nordiske miljømærke | Energy Star | TCO'06 |
|---|---|---|---|---|---|---|
| Strømforbrug i tændt tilstand | | | | | | |
| Strømforbrug i slukket tilstand | | | | | | |
| Strømforbrug i passiv standby | | | | | | |
| Strømforbrug i aktiv standby | | | | | | |
| Maksimum energiforbrug | | | | | | |
| Energieffektivitetsmærke | | | | | | |
| Generelle ecodesignkrav | | | | | | |
| Demontage | | | | | | |
| Levetidsforlængelse | | | | | | |
| Kemikalier | | | | | | |
| Grønne indkøb | | | | | | |
| Informationskrav | | | | | | |
| Miljøledelsessystem | | | | | | |

En stærk markedstrend i øjeblikket er, at skærmstørrelserne bliver større og større. Forbrugsmønstret skifter fra mindre forholdsvis energieffektive skærmstørrelser <30" til større skærmstørrelser >40" med større energiforbrug (med mindre der sker teknologiskift). Mens miljømærkerne og Energy Star har taget højde for dette ved at sætte et maksimum krav på henholdsvis 200 W og 108 W i tændt tilstand, har IM har ikke taget højde for denne trend – nærmest tværtimod.

I fjerde del af denne rapport bliver nye teknologier sammenlignet med miljømærkerne og IM. Miljømærkede TV fra Samsung, Sony og Philips er analyseret. Samsung og Philips benytter den nye LED teknologi, hvorimod Sony og Philips har integreret forskellige energisparende funktioner i TV'et for at spare på energiforbruget. Alle TV kan nemt opfylde kravene i IM for standby og tændt tilstand og de øvrige krav i miljømærkerne**. Med andre ord har gennemførelsesforanstaltningerne ikke været i stand til at tage nyudviklede teknologier og nye energisparende funktioner i betragtning og derfor vil kravene heller ikke være innovationsdrivende på miljøområdet.** Derudover har de analyserede TV i 2011, et synligt lavere energiforbrug end kravene i miljø- og energimærkerne foreskriver. Enkelte TV producenter markedsfører TV uden miljømærke, som har lavere energiforbrug end TV med et miljømærke. Dette er problematisk eftersom formålet med miljømærkerne netop er at repræsentere og fremme de bedste produkter.

Derforuden er fjernsyn baseret på velkendte teknologier undersøgt, da det er forventet at disse måtte have sværest ved at kunne overholde kravene i IM. TV fra Samsung, Sony, LG, Grundig, Panasonic og Bang & Olufsen er undersøgt, repræsenterende Full HD og HD ready teknologier, forskellige skærmstørrelser samt LCD og plasma teknologier. Resultaterne er, at 16 af de 35 undersøgte TV kan overholde kravene til strømforbrug i tændt tilstand for 2012. 15 TV kan kun overholde kravene gældende fra 2010 og fire fjernsyn kan ikke overholde nogen af kravene. Med hensyn til krav til standbyforbrug har fire af de seks TV-producenter TV i deres produktportefolie, som kan overholde kravene i 2011, mens alle undersøgte fjernsyn kan overholde kravet, der trådte i kraft i januar 2010.

Konklusion

På baggrund af dette studie af de produktorienterede politikker rettet mod at forbedre fjernsyns miljømæssige egenskaber, så kan der især fremhæves tre hovedkonklusioner, samt en række styrker og svagheder ved især den måde kravene til fjernsyn implementers i EuP direktivet.

Den første hovedkonklusion er, at potentialet i EuP direktivet ikke er blevet udfoldet fuldt ud, idet fokus ud fra en livscyklusvurdering har været på de væsentligste miljøpåvirkninger, hvilket med de givne betingelser har været relateret til energi i brugsfasen. Dette har ført til opstilling af udelukkende energieffektivitetskrav, mens andre forbedringspotentialer ud fra et eco-design rationale er blevet negligeret. Tilsvarende er teknologi- og markedstrends ikke blevet vurderet tilbundsgående, hvilket fører frem til de to andre hovedkonklusioner.

Den anden hovedkonklusion handler om, at hvis målet er energibesparelser, så er EU kravene udformet på en måde, som kun kan betegnes som et selvmål. Tilbage i tiden før 2005 var relativt små skærme på over 21-27" de mest udbredte og havde samtidigt et forholdsvis begrænset energiforbrug under 100W (det tilladte i 2012 for 21" er 54W). Efter 2005 eksploderer markedet for fladskærme imidlertid, og skærme på 42-46" bliver de mest udbredte, og med et tilladt energiforbrug på mellem 180-210W i 2012. I og med at EU udformer energieffektivitetskravene, så at større skærme også er tilladt et større energiforbrug, så betyder markedstrenden med de store skærme, at energibesparelsen rundt regnet (og alt andet lige) er forduftet – eller måske ligefrem at energiforbruget ved TV vil blive større. Konklusionen er derfor, at kommisionen seriøst må overveje forbruger- og markedstrend, hvis de intenderede fordele skal opnås – og ikke opsluges af rebound effekter.

Så galt går det dog nok ikke, idet alt andet ikke kan holdes lige. Den tredje hovedkonklusion handler således om, at den teknologiske udvikling og producenterne er kommet kommisionen til hjælp, idet især LED back-light på fladskærmene betyder, at der i 2012 sælges nye LED TV, som faktisk ligger under det halve energiforbrug af de skærpede krav; hvor de bedste 42" TV har et forbrug på knap 60W, som er 1/3 af det tilladte i det skærpede krav i 2012. De opstillede krav til TV under EuP direktivet har (måske) været med til at øge fokus på energieffektivitet i produktudviklingen af nye fjernsyn, men kravene er allerede i dag tæt på at være forældede på grund af den teknologiske udvikling på området.

Baseret på de gennemførte undersøgelser kan følgende konklusioner om *styrkerne* i IM fremhæves:

- **EuP direktivet vil fjerne de mindst energieffektive produkter fra det europæiske marked.**

Minimumskravene i IM sikrer, at de mindst energieffektive produkter ikke vil blive solgt på det europæiske marked, og at der er et overordnet incitament til producenterne om at fabrikere energieffektive produkter.

- **Energieffektivitetsforbedringer er i fokus, og potentielt kan andre miljøforbedringer inkluderes**

Minimumskravene åbner for muligheden for en forbedret energieffektivitet, og potentielt kan øvrige miljøhensyn inkluderes i de generiske eller specifikke krav i IM. Det vil dog kræve et udvidet fokus i forhold til de nuværende IM.

- **Reguleringen er knyttet til innovation og tilgangen er dynamisk (kravene strammes gradvist)**

Minimumskravene strammes gradvist i henhold til den forventede teknologiske udvikling. På energieffektivitetsområdet for TV kender producenterne kravene fire til fem år, før de træder i kraft. De opstillede minimumskrav bliver revideret regelmæssigt for at tage højde for den teknologiske udvikling, (hvilket parantetisk bemærket i den grad er nødvendigt i forhold til TV).

- **Minimumskrav som i EuP kræver et koordineret samspil med andre politiske redskaber.**

Det er nødvendigt med en evaluering af synergien mellem forskellige politiske redskaber for at finde momentum mellem minimumskrav og markedsincitamenter til frontløbere via miljømærkerne og grønne indkøb.

På den anden side er der også *svagheder og begrænsninger* i den nuværende fremgangsmåde med opstilling af krav til energiforbrugende produkter (EuP):

- **Snævert fokus på energieffektivitet i stedet for miljømæssige forbedringer**

Inspireret af anbefalingerne i forstudierne fokuserer IM udelukkende på energieffektivitet. Åbenlyse miljømæssige forbedringer, såsom ressourceeffektivitet er ikke medtaget i IM. I stedet henviser IM til RoHS og WEEE direktiverne for regulering af kemikalier og affald. Som det eneste inkluderer IM en forpligtelse til producenterne om at informere forbrugeren, hvis TV'et indeholder kviksølv eller bly. Denne informationsforpligtigelse kunne udvides til at inkludere alle kemikalier noteret på listen over særligt problematiske stoffer i REACH forordningen.

- **Fokus på energieffektivitet i brugsfasen i stedet for hele produktets livscyklus**

I forstudierne blev energiforbruget i brugsfasen fremhævet som den største miljøpåvirkning fra et fjernsyn. Derfor fokuserer IM udelukkende på denne fase af produktets livscyklus. Et studie fra European Environmental Bureau fremhæver, at metoden brugt i forstudierne (MEEuP) overestimerer betydningen af brugsfasen på grund af de afgrænsninger der er gjort og den levetid fjernsyn er tildelt i metoden (van Rossem and Dalhammar, 2010). Der kan således sættes spørgsmålstegn ved resultaterne af den udviklede metode til vurdering af et produkts miljøpåvirkning, hvilket tilsyneladende er medvirkende til det yderst ensidige fokus i IM på energi i brugsfasen.

- **Gennemførelsesforanstaltningerne udfordrer ikke relationen mellem energieffektivitet og skærmstørrelse**

Skærmstørrelsen er en af parametrene i ligningen til udregning af kravet for energiforbruget i tændt tilstand, og IM accepterer uden videre at større skærme bruger mere strøm. Dette er et dilemma for energieffektiviteten, idet markedstrenden går mod større og større skærme. Med andre ord, kan de forventede energibesparelser blive modvirket af de større skærme. Det nordiske og europæiske miljømærke har begge taget højde for denne trend ved at sætte krav til et absolut maksimum energiforbrug på 200W uanset skærmstørrelse. Mens Energy Star har sat den øvre grænse ved 108 W. Dette er en udfordring for de fleste fjernsyn over 40", mens nye teknologier, som eksempelvis LED baserede TV kan overholde dette krav.

- **EuP processen er for lang**

I tilfældet med TV er en EuP arbejdsproces på fire år for lang. Resultaterne af denne rapport viser, at IM ikke har været i stand til at tage den hurtige teknologiudvikling i betragtning, selvom der blev forsøgt taget højde herfor i forstudierne. Reguleringsprocessens hastighed kan øges signifikant ved at opbygge en fælles informationsplatform og evidens base for produktrelaterede direktiver samt ved miljømærker og grønne indkøb.

- **Nye teknologier er ikke blevet taget i betragtning**

I forstudierne er det forsøgt at inkorporere overvejelser om nye teknologier, hvorfor forstudierne og IM fokuserer på LCD og plasma. Det er dog i denne rapport fundet at forstudierne og IM ikke har kunnet forudse introduktionen af nye teknologier som eksempelvis LED. Dette afspejles i IM og allerede i 2010-11 har mange fjernsyn et strømforbrug i tændt tilstand MARKANT under kravet i IM for 2012.

- **IM kunne være mere ambitiøse særligt for krav til energiforbruget i tændt tilstand**

Kravene i IM kan være mere ambitiøse på to områder; energiforbrug i tændt tilstand og for andre miljøkrav. Som vist kan tilnærmelsesvist alle undersøgte fjernsyn på markedet i 2011 overholde IM. Derfor vurderes det omkring TV, at IM ikke fremmer miljøvenlig innovation.

Endelig kan der fremføres en række kritikpunkter af mere *perspektiverende* karakter, som handler om det forholdsvis snævre fokus på produkter. Disse forhold har end ikke været overvejet i EU regi, så på den måde ligger de op til en udvidet forståelse af produktets funktion og dets livscyklus. Tre områder kan i denne sammenhæng fremhæves, som bør tages i betragtning ved det fremtidige arbejde med EuP Direktivet især i relation til IKT produkter:

- **Produktintegration er ikke medtaget som et potentiale for miljøforbedringer**

Der findes mange eksempler på produktintegration på markedet i dag, for eksempel fjernsyn med integreret DVD, USB etc. og inden for de næste år vil Internet og pc-funktionaliteter også blive integreret. Produktintegration er ikke en del af IM, selvom der er potentiale for miljøforbedringer både i forhold til energi- og ressourceeffektivitet.

- **Indlejret energi og ressourceforhold er en "blind vinkel" i EuP**

Den indlejrede energi i materialerne i et fjernsyn er ikke taget i betragtning. Dette kan fremover være ensbetydende med stigende brug af energiintensive materialer, som for eksempel aluminium. Ligesom sjældne jordarter og begrænsede ressourcer heller ikke er overvejet. Disse forhold tematiseres først for alvor med EU's Roadmap for Ressourceeffektivitet fra efteråret 2011.

- **Pædagogiske elementer er udeladt**

Ved de første udkast til EuP direktivet var intentionen, at producenter skulle lave en miljøprofil af deres produkter og lade denne guide det videre arbejde med produktets miljøpåvirkning. Dette blev siden udeladt, og derfor der er således ingen vejledning til producenterne om hvilke aspekter ved produkterne der løbende kan forbedres som for eksempel øget brug af genanvendelige materialer, mv. Tilsvarende er der heller ikke tænkt synderligt i informative virkemidler i forhold til at påvirke forbrugernes sociale praksis omkring anvendelsen af fjernsyn, hvorved nogle oplagte besparelsespotentialer går tabt.

# Summary and Conclusions

The focus of this report is the implementation of the EU Directive 2005/32/EC on ecodesign requirements for energy using products (the EuP Directive) with special attention to the ecodesign requirements for televisions (TV). The aim is to investigate the scope of the Implementing Measures (IM), how ambitious the requirements of the IM are, and to what degree they can promote eco-innovations of TVs. In the following the main conclusions are highlighted in bold.

The report consists of five parts:

- Definition of ecodesign
- The EuP process: from preparatory study to Implementing Measures
- The relations between EuP Implementing Measures and the different energy and environmental labelling schemes
- New market and technology trends compared to requirements of Implementing Measures and ecolabelling
- Analysis of the EU Energy labelling scheme for TVs

In the first part, the ecodesign concept is defined as including all environmental aspects in a products entire life cycle. The EU has responded to this approach through integrated product policy (IPP). This approach includes both voluntary and mandatory measures, aiming at either setting minimum requirements or creating incentives for frontrunner companies to move even further.

In the second part, the scope of the recommended requirements of the preparatory study and the IM are compared. The preparatory study takes a comprehensive approach to the environmental impacts of TVs, though strongly emphasising that the most important environmental impact is the power consumption in the use phase. However, **the Implementing Measure has a narrow focus on power consumption of television in standby, off- and on-mode.** The IM followed the recommendations on standby power consumption set forth in the preparatory study. The preparatory study was completed by a consortium considtsinting of five partners, and Fraunhofer IZM as project leader. In the IM the requirement for on-mode power consumption are tightened and the requirement for off-mode slackened compared to the recommnedations in the preparatory study. When it comes to requirements on for instance chemicals and recycling, the IM refer to the RoHS Directive and the WEEE Directive in general terms.

The preparatory study began in February 2006 and the consortium presented the final study in August 2007. The European Commission passed the IM as Commission Regulation in July 2009; and televisions have to fulfil the first requirements from January and August 2010. A EuP process of four years put high demands on the preparatory study and IM to investigate emerging technologies. The preparatory study has to some extent considered obsolete and new technologies. Some obsolete technologies were excluded from the research such as CRTs, and the emphasis was put on technologies that by the consortium were assessed to be market leading in the future such as LCD and Plasma. However, **the preparatory study and IM have not been able to take**

**into account new emergent technologies** with interesting properties from an environmental viewpoint. For example, TV's based on LED technology are significantly more energy efficient (see Figure 5-1 and Figure 5-3) than the requirement of the IM, and at the same time without mercury, but this technology – with a significant market introduction in 2009 – have not influenced the minimum requirements, since it was assessed too immature to have an influence.

In the third part of this report, the level of ambitions of EuP Directive is investigated by comparing the four ecolabels (European Ecolabel, Nordic Ecolabel, Energy Star and TCO'06) to the IM. The main findings are that the IM have a narrow focus on energy consumption, whereas most of the ecolabels focus more holistically on environmental impacts of the product. As expected, **the Implementing Measures set less strict requirements than all the ecolabels,** except for standby power consumption, where the requirements fit approximately with the ecolabels. Content of mercury, flame retardants as well as life time extension and dismantling are all examples on criteria from ecolabelling that are not dealt with in the IM.

Table 0.1 Focus of the preparatory study, the IM and ecolabels. The green colour illustrates the primary focus and the yellow colour illustrates the secondary focus.

| Subject | Preparatory Study | IM | European Ecolabel | Nordic Ecolabel | Energy Star | TCO'06 |
|---|---|---|---|---|---|---|
| Power consumption on-mode | | | | | | |
| Power consumption in off-mode | | | | | | |
| Power consumption in passive standby | | | | | | |
| Power consumption active standby low | | | | | | |
| Maximum energy consumption | | | | | | |
| Energy efficiency label | | | | | | |
| General eco-design requirements | | | | | | |
| Dismantling | | | | | | |
| Life-time extension | | | | | | |
| Chemicals | | | | | | |
| Green procurement | | | | | | |
| Information requirements | | | | | | |
| Environmental Management system | | | | | | |

A significant market trend is towards bigger and bigger flat screens. The consumption pattern is changing from small, rather energy efficient screens <30" to large screens >40" with high energy consumption. The IM is not considering this market trend, while the ecolabels and the Energy Star have put a maximum of 200 W and 108 W, respectively, as an upper limit for energy consumption.

In the fourth part, new technology trends are compared to ecolabels and IM. Ecolabelled TVs from Samsung, Sony and Philips are anlysed. Samsung and Philips make use of the new LED technology, whereas Sony and Philips have implemented different energy saving functions in order to reduce power consumption. All brands can easily comply with the IM regarding on-mode and standby power consumption and with the other demands of ecolabels. In other words, **the Implementing Measures have not managed to take into account emergent technologies and new energy efficiency functions, and therefore the requirements will not be a direct trigger for eco-innovations.**

Furthermore, the TVs analysed in 2011 have visibly lower power consumption than the requirements of the ecolabels and some brands have non-ecolabelled TVs, which perform better than the ecolabelled TVs. This is challenging since the purpose of the ecolabels is to represent the best performing products.

Furthermore, TVs based on well-known technologies are investigated as they could have difficulties in complying with the IM. TVs from Samsung, Sony, LG, Grundig, Panasonic and Bang & Olufsen are analysed, representing both full HD and HD ready technologies, different screen sizes and plasma and LCD technologies. The findings are that 16 of the 35 investigated TVs can comply with the 2012 requirements for on-mode power consumption. 15 TVs can only comply with the 2010 requirement and four cannot comply with any of the on-mode power consumption requirements. With regards to standby power consumption, four of the six TV manufacturers have TVs in their product portfolio, which can comply with the 2011 requirements, and all analysed TVs can comply with the standby requirements that came into force January 2010.

The final chapter of the report analyses the requirements of EU's mandatory energy labelling scheme for TVs. The labelling scheme includes all TVs on the market and allocates a label from A+++ to G to TVs depending on their energy efficiency. It is interesting to note that also in this scheme the EuP IM are clearly minimum requirements, as the products that just can comply with the IM have low efficiency labels. Also it is interesting that the schemes' most efficient labels demand significantly higher energy efficiency than ecolabels,. However, the time span of the EU energy-labelling scheme is also longer than any of the ecolabels.

## Conclusion

Based on this study of the product-oriented policies in the EU regarding the improvement of TVs' environmental properties, three main conclusions will be hightlighted as well as some strengths and weaknesses especially regarding the way the requirements are set up in the EuP Directive.

The first main conclusion is that the potential of the EuP Directive has not been fully realized, since the focus based on a life cycle assessment has been on the most significant environmental impacts, which from delimitations of the study has been related to energy consumption in the use stage. On this background, only requirements related to energy efficiency have been set up, while other improvement potentials based on an ecodesign rationale have been neglected. In the same way, the technology and market trends have not been carefully investigated, which leads to the following main conclusions.

The second main conclusion is, if the overall objectives of the EU are energy savings, then the minimum requirements have been set up in a way that makes this rather unlikely. Before 2005, televisions were rather small with screens between 21"-27" as the most common, and with relatively low energy consumption below 100W (the required in 2012 for 21" is 54W). After 2005 the market for flat screens "exploded" and screens between 42"-46" has today become the most common, and with a maximum allowed energy consumption between 180-210W in 2012. In other words, since EU has set up the requirements in a way that allows bigger screens to have a bigger energy consumption, then the market trend with bigger and bigger screens turned on for longer periods means that the energy savings have "disappeared" (all things being equal) – or perhaps even that the energy consumption from TVs will grow. The commission seriously needs to investigate the consumer and market trends, if the intended potentials of energy savings shall be achieved – and not be counteracted by rebound effects.

These risks are however marginal, since everything else can't be kept equal. The third main conclusion is that the technological development and the manufacturers have secured that the energy savings potentials can be achieved. Especially, the development of LED backlight ultra-thin flat screens means significant energy efficiency of the new TVs. In 2012 the requirements in the IM on TVs are tightened significantly, but already in 2011 the energy efficiency of the major brands were easily able to comply with the new requirements as energy consumption was just half of the tightened requirements. One of the best performing 42" TVs had in fact an energy consumption of nearly 60W, which is around 1/3 of what is allowed with the tightened requirements. The requirements of the EuP Directive has (perhaps) been part of getting more focus on energy efficiency of TV, but the requirements are today close to being outdated due to technological developments.

Based on the investigations, the following conclusions on the *strengths* of the IM are emphasised:

- **The IM will expel the most energy inefficient products from the European market**

The minimum requirements of the IM will ensure that the most energy inefficient products are not sold on the European market.

- **Improvement of energy efficiency is the core focus, and potentially environmental improvements could be included**

Regulation with minimum performance standards opens up for improvement of energy efficiency. Potentially, environmental improvements can be incorporated in the requirements as well, but this will require a change of the current scope of IM.

- **Regulation is connected to innovation and with a dynamic approach (gradually stricter requirements)**

The minimum performance requirements are gradually tightened according to the expected technological development. In the case of energy efficiency of TV, the manufacturers will know the standards four-five years ahead. The EuP Directive and the IM are also revised on a regular basis to grasp the technological improvements.

- **Minimum performance demands as in EuP requires a coordinated interplay with other policy instruments**

An evaluation of the synergy between the different policy instruments is needed in order to find the momentum between minimum performance requirements (IM) and market incentives to frontrunners as in the case of ecolabelling and green procurement.

On the other hand, there are also weaknesses and limitations in the current approach to EuP:

- **Narrow focus on energy efficiency instead of environmental improvements**

Based on recommendations from the preparatory study the IM only focuses on energy efficiency. Obvious potentials for environmental improvements for instance on resource efficiency are not included. The IM refer to the RoHS and WEEE Directive for matters concerning chemicals and recycling of TVs. The IM already require producers to inform the consumers if the TV contains mercury or lead. This information requirement could be expanded to cover all the Substances of Very High Concern of the REACH regulation.

- **Focus on energy efficiency in the use phase instead of the entire life cycle of the TV**

In the preparatory study, energy consumption in the use phase was highlighted as the most important environmental impact of TV. Therefore, the IM exclusively focus on this phase of the products life cycle. In a recent study by the European Environmental Bureau, it is argued that the MEEuP in the case of televisions, computers and monitors the methodology is overestimating the use phase, due to the boundaries of the methodology and the life span applied (van Rossem and Dalhammar, 2010). It is unfortunate, if it is possible to question the results of the very method used for assessing the products environmental impact, and that it possibly is the reason for the IM narrow focus on the use phase.

- **The IM does not challenge the relation between energy efficiency and screen size**

The screen size is one parameter in the equation for calculating the power consumption requirement, and IM accepts that larger screens use more power. This is a dilemma in terms of energy improvements due to the significant market trend towards larger screen sizes. In other words, the energy saving potentials due to the energy efficiency requirements in IM can be counteracted by the bigger TV screens. Both the Nordic and the European Ecolabel has taken this into account and set a maximum power consumption of 200 W, whereas the Energy Star has set the upper limit to 108 W. This is a challenge for most screens bigger than 40'', but new technologies such as LED are able to comply with the requirement.

- **The EuP process is too long**

In the case of TVs, a EuP work process of four years is too long. From the findings of this report it is clear that the IM have not been able to take into account the fast technological development, even if it was considered in the preparatory studies. The speed of the process needs to be improved significantly for instance through building up a common information platform and evidence base for EuP, ecolabels and green public procurement.

- **Emergent technologies have not been taken into account**

In the preparatory study, the authors have tried to incorporate considerations on emergent technologies, and therefore the study focuses on LCD and Plasma. However, as shown in this study, the EuP preparatory study and IM has not foreseen the market introduction of emergent technologies such as LED. Hence the IM do not reflect these new technologies and many TVs have already today on-mode power consumption significantly lower than the requirements for 2012 of the IM. Naturally, it is a balance which technologies that should set the standard as for what can be considered a minimum environmental performance. On one hand new technologies should be included in order to constantly follow the technological development and update the requirements accordingly. On the other hand smaller producers do often not have access to the new technologies as soon as the bigger producers and if minimum requirements are set too high to soon because of new technological developments there is a risk that smaller producers are excluded from the market.

- **The IM could be more ambitious especially regarding on-mode power consumption**

The IM can be more ambitious on two points; on-mode power consumption and other environmental requirements. As shown, almost all the analysed TV on the market today can already comply with the IM, and therefore the regulation will not promote eco-innovations directly.

Finally, based on the experience gained from this study at least three issues can be highlighted that future work related to EuP has to take into account:

- **Product integration is not considered as a potential for environmental improvements**

Today, tendencies towards product integration are present such as TV with DVD, USB, etc. integrated, and within the next years integration with computers and the internet will be common. Product integration is not reflected in IM, even though this could have potentials for environmental improvements both in terms of energy efficiency and material savings.

- **Embedded energy is another "blind spot" in EuP**

The embedded energy in the materials applied in TV is not taken into account, which can become significant in the future with the increasing use of high energy intensive materials such as aluminium, etc.

- **Pedagogical elements are left out**

Since the first drafts of the EuP Directive the intention of having the manufacturers make an eco-profile of their products and let this guide the design solutions has vanished. Now the manufacturers only have to take into account the requirements of the IM and are no longer forced to learn more about their products' life cycle impact on their own. See also (van Rossem and Dalhammer, 2010).

# 1 Ecodesign

Once a product leaves the production facilities the producer has little influence on how the product is being used and its environmental impact. However, through smart design of the product, where the producers in the design phase integrate environmental considerations of the product's entire life cycle, the producers do have the opportunity to influence the product's environmental impact after it leaves the factory. This integration of environmental criteria in the design is also called ecodesign.

Basically, ecodesign means environmentally conscious product development (Tischner, 2006). In practice, environmental considerations are added to the other considerations in the design of new products such as economic, safety and quality issues. Ecodesign covers the product's entire life cycle, from the extraction of raw materials, production, transport, use, recycling and disposal. All relevant environmental properties should be addressed, including material and energy efficiency, emissions and hazardous substances. The aim of ecodesign is to fulfil a need with the least environmental impact, meaning that the function of the product should be the point of departure for product development (Tischner, 2006).

One of the first guidelines for businesses on how to do ecodesign was made in 1997 by Han Brezet and Carolien van Hemel (Brezet and van Hemel, 1997). The authors presented the ecodesign strategy wheel, which visualises the steps and strategies that can be followed in ecodesign (see Figure 1-1).

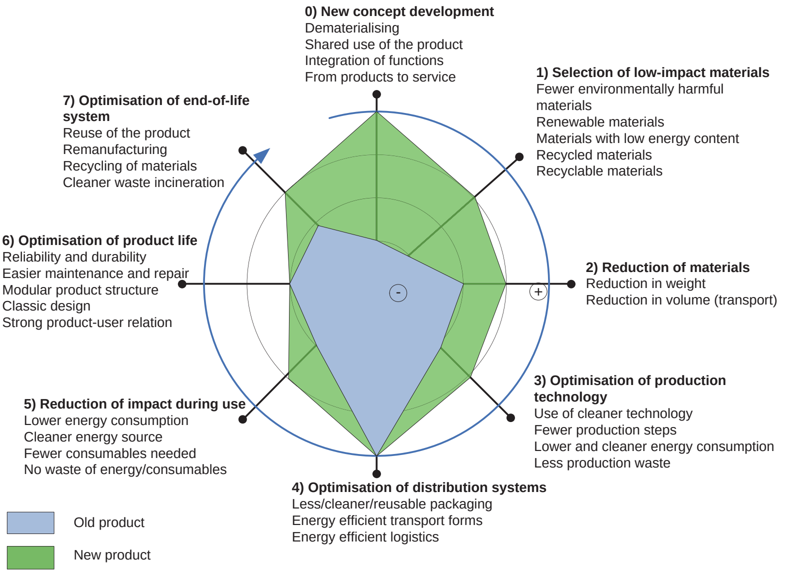



Figure 1-1 The ecodesign strategy wheel (Brezet and van Hemel, 1997)

From Figure 1-1, life cycle thinking in ecodesign becomes visualized, and the different strategies are highlighted in order to improve the environmental properties of the product at different stages. The centre of the figure is a spider web, illustrating the environmental profile of the product. In this case the blue shape illustrates the profile of the existing product and the green shape the new ecodesigned product. Right from the beginning, eco-design has focused on improvement potentials of products and services, and not just on analysis of the environmental impacts as in life cycle assessment.

## 1.1 Integrated Product Policy

The EU has introduced life cycle thinking in their Integrated Product Policy (IPP) that was developed in cooperation between the Commission and stakeholders in the late 1990's. IPP was first discussed at a meeting in 1998 and is based on five key principles. The first is *life cycle thinking* and means considering the entire product life cycle and its environmental impacts. This aims at considering both the cumulative environmental impacts and avoiding burden shifting, where environmental impacts in a single life cycle phases are addressed with the result of increasing the impact in another life cycle phase. IPP is an integrated approach aiming at promoting measures to reduce the environmental impact of products at a point where this is most effective. (European Commission, 2003a)

Further key principles of IPP are:

- *Working with the market* meaning that IPP should create incentives for business to be innovative and forward thinking.
- *Stakeholder involvement* means that IPP should encourage all stakeholders e.g. industry, consumers and governments to use their influence in promoting greener products.
- *Continuous improvement*, where business can set the pace, rather than setting specific limits and goals.
- *A variety of policy instruments* is the final principle. The instruments to be used within IPP are manifold from voluntary initiatives to regulations. (European Commission, 2003a)

IPP was introduced by EU as a reaction to the fact that the quantity, variety and complexity of products is increasing, new types of products are constantly introduced to the market and products are now more than ever traded globally. This means that more actors are involved throughout the products' lifetime and have an influence on the environmental impact of the product. (European Commission, 2003a)

### 1.1.1 Implementation of IPP

Since the IPP approach was first introduced several legislations have been implemented. In particular three Directives are relevant for this report:

- Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
- Directive 2002/96EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)
- Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products (EuP)

The three legislations have been implemented in different ways, and some more successful than others. When adopting new or revising existing legislation it is a constant concern not to introduce double regulation, where several legislations regulate the same issue. It is a subtle balance to develop regulations on issues closely related without confusing regulators, businesses and consumers. In the following the aim and actual implementation of the three directives is briefly described. The purpose is to illustrate the synergies and lack thereof between the three regulations and hence investigate if double regulation is a problem.

**The RoHS Directive**

The RoHS Directive restricts the use of certain chemical substances in electronic and electrical equipment. The restriction concerns cadmium, lead, mercury, hexavalent chromium, poly-brominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE), in quantities exceeding maximum concentration values. The aim of the Directive is in this way "*to contribute to the protection of human health and the environmentally sound recovery and disposal of waste electrical and electronic equipment*" (European Commission, 2003b, p. 1). If electrical and electronic products do not comply with the Directive, the products are not allowed to be sold in the EU, and the national authorities are cooperating on spotting such products and removing them from the market (Europa, 2008).

According to the Commission the RoHS Directive has prevented several thousand tonnes of the prohibited substances from being placed in the products and design practices in this matter have changed also in countries outside the EU. However, compliance checks in EU member states have revealed that up to 44% of the EEE that was checked for compliance does still not comply with the Directive. (European Commission, 2008)

**The WEEE Directive**

The WEEE Directive sets marking requirements to producers and importers and establishes an individual producer responsibility for the take-back and treatment of WEEE. The latter makes the producer economically responsible for the take-back and environmentally friendly treatment of WEEE. The producer can comply with this regulation individually or by joining collective schemes. The WEEE directive also sets requirements as to the recovery rates of the products in scope. The purpose of the WEEE Directive is, *"as a first priority, the prevention of waste electrical and electronic equipment (WEEE), and in addition, the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste. It also seeks to improve the environmental performance of all operators involved in the life cycle of electrical and electronic equipment, e.g. producers, distributors and consumers and in particular those operators directly involved in the treatment of waste electrical and electronic equipment"* (European Commission, 2003c: art. 1).

The idea behind the Directive is to make the producer responsible for the end of life stage of their products. In principle, this gives an economic incentive for the producer to integrate considerations about the product's end of life phase and recycling options in the design phase of the product. A recent study has however revealed that only seven member states have fully implemented the individual producer responsibility and seven member states have ignored the implementation of the individual producer responsibility completely (van Rossem and Dalhammar, 2010). In the latter countries the producers can join collective schemes, where they are not financially responsible for the take-back of exactly their products, but the payments are based on averages. In these member states, the incentives for ecodesign are diminished significantly (van Rossem and Dalhammar, 2010), and it is questionable whether the WEEE Directive serves its purpose on ecodesign at all.

### The EuP Directive

The EuP Directive establishes a framework for setting ecodesign requirements for energy using and energy related products. The ecodesign requirements are set up in implementing measures. The objective of the Directive is to ensure free movement on the market of products in compliance with the ecodesign requirements and *"it contributes to sustainable development by increasing energy efficiency and the level of protection of the environment, while at the same time increasing the security of the energy supply"*(European Commission, 2009a: art. 1.2).

Analysing the implementation of the Directive, then the focus in the Implementing Measures is highly towards only setting requirements for the energy consumption in the use phase, and hence not at all on an integrated life cycle thinking. A more thorough analysis of the implementation of the Implementing Measures for televisions is presented in Chapter 3 of this report. Based on findings in this study and the study of van Rossem and Dalhammar (2010) it can be argued that the EuP Directive does not fulfil the objective of the Directive, as it does not set up requirements for more than energy efficiency in the use phase.

The three directives focus rather narrowly on different aspects: hazardous substances, waste and energy consumption. Plus different product stages are in focus: choise of materials in the design stage, handling of waste at the end of life stage, and energy efficiency in the use stage. These different focuses are further strengthened by involving different professionals that are even employed in different agencies. This can be illustrated as in Figure 1-2.

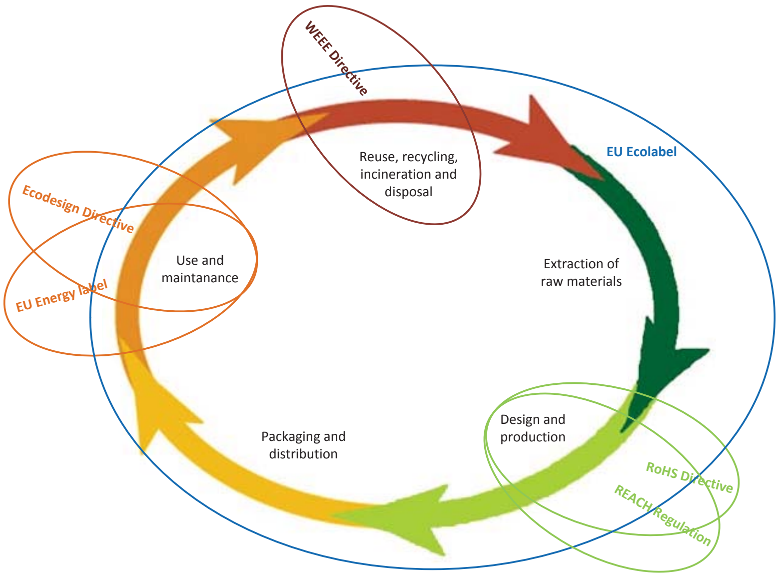



Figure 1-2 The focus area of the different regulations

In other words, the common objective on ecodesign – environmental improvement in all life cycle stages – has faded away, and in stead each directive focus on one issue and in one life cycle stage. This creates a challenge of securing synergy between the different directives and avoiding double regulations as well as obtaining the linkage between legislative regulations with minimum requirements and voluntary measures with incentives for front-runners.

**Synergy between the three directives**

It is a balance on the one hand to develop regulations that regulate the environmental impacts of products in a life cycle perspective and on the other hand not to create inexpedient double regulation. However, the objective of the EuP Directive cannot be fulfilled without looking at the entire life cycle of the product and setting requirements to several environmental impact categories.

From the above overview, especially the WEEE Directive does not fulfil its objective on ecodesign, and more specific requirements on design for recyclability, etc. can be put forward in the EuP Implementing Measures without compromising with the current WEEE Directive. The RoHS Directive has to some degree fulfilled its objectives, but improvements can be made. If chemical requirements should be included in the IM it could be with references to the existing regulation and/or it could be an information requirement on the chemical content of the product.

As the existing regulations only to some degree fulfil their objectives regarding eco-design it is our assessment that the EuP Directive, without compromising with other regulations, could encompass requirements on the environmental impact of the entire life cycle of the products. This can also be done without creating confusion among regulators, producers and consumers.

As indicated in Figure 1-2 above, two other policy instruments are important: the EU mandatory energy label and the different ecolabels.

**Synergy between the Directives, Energy-labelling and Voluntary Measures**

The EuP, RoHS and WEEE Directives are the mandatory legislations, but also Energy-labelling has become mandatory for most electronics. The European Ecolabel, the Nordic Swan and Green Public Procurement are all voluntary measures. The intention is that both mandatory and voluntary measures are needed to create incentives for production and marketing of cleaner products. The mandatory measures set minimum requirements (except WEEE), whereas voluntary measures focus on criteria that go beyond compliance and create incentives for front-runners.

In this report the EuP requirements of the Implementing Measures for televisions are compared to the requirements of the different ecolabels for televisions. The intention is to see how a synergy can be created between the minimum requirements in EuP and the criteria for ecolabelling – in other words, how to strike a balance between minimum requirements that expel product with bad performance from the market and then criteria that give a competitive edge to the "good guys" in industry. The two policy instruments aims at completely different target groups and serve different purposes, but still a the relation between minimum requirements and criteria for eco-labelling is important in order to create synergy and fullfill the overall aim of the different policy instruments. Figure 1-3 illustrates the scope for the two types of policy measures.

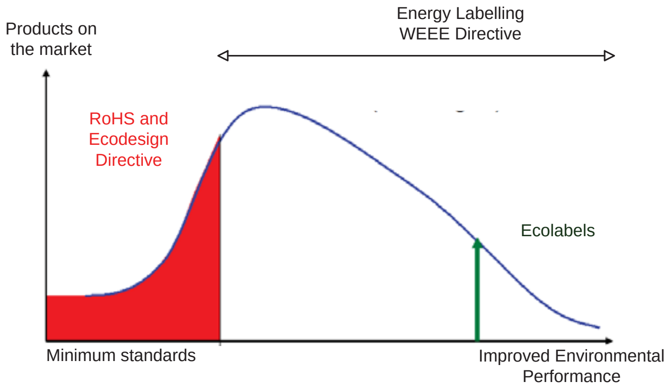



Figure 1-3 Scope for different IPP measures

As Figure 1-2 illustrates, RoHS and EuP set minimum standards for products' environmental performance, thereby removing the worst performing products from the market. On the other side of the scale the ecolabels set criteria with the aim that only the best performing products on the market can fullfil. The ecolabels are continuously updated and tightened to ensure that only the best performing products can comply with the requirements. In this way the ecolabels create incentives that push the market towards more environmentally friendly products. The Energy Labelling covers the entire span of products on the market with the aim of informing the consumer of the performance level of the given product. The specifics of the Energy Labelling are analysed in Chapter 6.

The comparison of the IM and ecolabels is made in order to analyse, which environmental aspect the ecolabels have setup requirements for and which are not regulated in the IM of the EuP Directive. By applying the approach it is acknowledged that behind the ecolabels lies years of work and experience with setting environmental requirements that could have been utilised in the process of setting requirements in the IM.

# 2 Preparatory Study LOT 5 – Consumer Electronics: TV

In this chapter the preparatory study of televisions is analysed. The aim is to assess, which environmental impact categories were included in the IM for televisions, and to analyse how these requirements were set up.

## 2.1 Description of LOT 5

The preparatory study on LOT 5 Consumer Electronics: TV was launched in February 2006 and the final report was published in August 2007. A consortium consisting of five partners completed the study. Fraunhofer IZM was the project leader; further partners were Öko-Institut, BIO Intelligence Service, Deutsche Umwelthilfe, PE Europe, and CODDE. (ecotelevision, 2010).

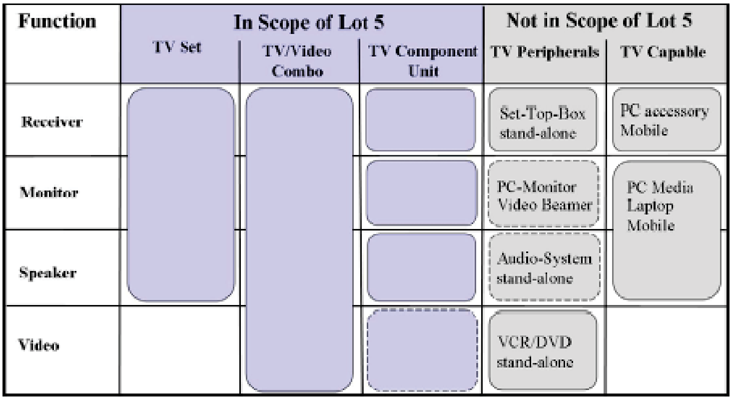
The preparatory study for LOT 5 consists of the following eight tasks:

- Task 1 "Definition"
- Task 2 "Economic and Market Analysis"
- Task 3 "Consumer Behaviour and Local Infrastructure"
- Task 4 "Technical Analysis"
- Task 5 "Definition of Base Cases"
- Task 6 "Technical Analysis BAT"
- Task 7 "Improvement Potential"
- Task 8 "Scenario, Policy, Impact, and Sensitivity Analysis"

Throughout the process relevant stakeholders among others the European Information & Communications Technology Industry Association (EICTA), Sharp, Pioneer and Panasonic were consulted, and they provided data and input to the study and gave comments on drafts before final publication. In each task the authors have published the stakeholder comments and commented them. The specific methodology for the study will not be elaborated in detail here, but a complete presentation is available on the European Commission's homepage http://ec.europa.eu/enterprise/eco_design/ecodesign.htm.

In Task 1 the authors investigated and defined the products in scope of the LOT 5. By investigating existing product categories and definitions for instance from ecolabels it was found that a homogeneous picture does not exist. On the contrary, a television (TV) can include many different functions and equipment types, and can be combined in several ways. This complexity is illustrated in Table 2.1.

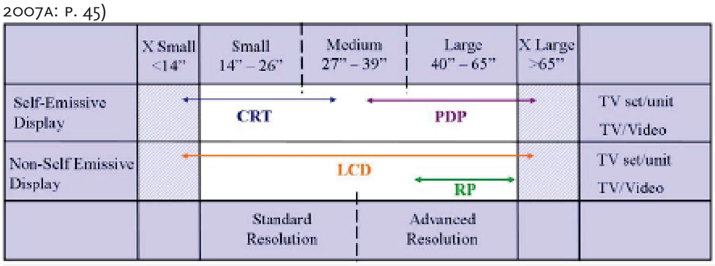
Table 2.1 TV functions and typical equipment types. From (Stobbe, 2007a, p. 15)




The scope of the LOT 5 is TV sets, TV/Video combination units and TV component units. Stobbe (2007a) argues that TV sets are the most economically significant product category[1] and therefore the main focus of the study. TV/Video combination units and TV component units are also within scope of the study as they are in widespread use. By including the TV component units LOT 5 recognises a modular approach to TVs. The study argues that it can be included as among other the Energy Star program includes the component units as a system if they can meet the same criteria as a stand alone TV. (Stobbe, 2007a)

After determining the scope of LOT 5, Stobbe (2007a) investigated the technical parameters that influence the environmental impact of the product. Especially, differentiation of the different display technologies and screen sizes are significant when measuring the TV's environmental impact. Stobbe (2007a) therefore differentiated between "self-emissive displays", such as Cathode Ray Tubes (CRT) and Plasma Panel Display (PDP) and "non-self emissive displays" such as Liquid Crystal Display (LCD) and Rear Projection (RP). In order to include the importance of the screen size the authors have divided the screen sizes into different ranges. (Stobbe, 2007a) See Table 2.2. The table shows the full range of TV screen sizes, but X-small and X-large are not in the scope of the study.

Table 2.2 Differentiation between screen sizes and display technologies. From (Stobbe, 2007a: p. 45)




Based on these findings Stobbe (2007a) focuses on two base cases; a 32" LCD-TV and a 42" PDP-TV. By selecting these to types of TVs the

[1] In 2005 more than 31 Million units where sold in the European Union, representing a value of more than 18 Billion Euro (Stobbe, 2007a, p. 14).

most prominent flat panel display technologies in the respective screen size are covered according to Stobbe (2007a). The products have been selected on the basis of expected future sales, as it would not represent a valid picture of the future environmental impacts if the investigation only focused on the products available on the market in 2006. Hence, the technologies CRT and RP are less important for the preparatory study as the CRT's are being phased out and the RP is not considered to have a growing market as are the LCD and PDP technologies. (Stobbe, 2007a)

## 2.2 Preparatory study on LOT 5

In the preparatory studies for LOT 5 five different areas have been identified as having an influence on TV sets' environmental impact (Stobbe, 2007c):

- Power consumption in on-mode
- Power consumption in standby
- Introduction of an energy efficiency label
- General eco-design requirements
- Chemicals

Furthermore, Stobbe (2007c) recommends requirements regarding environmental information and green procurement on the product. The authors recommend requirements for each of the mentioned areas, but it is strongly emphasising that the energy consumption has the most significant environmental impact (Stobbe, 2007c). In the following the seven areas will be elaborated

### 2.2.1 Power Consumption in On-mode

According to the study, the power consumption in the use phase is the cause of the primary environmental impact of TVs. In the study it is pointed out that in the past years power consumption in the use phase in European households has increased and reference is made to studies that show that it will continue to increase. Two reasons are emphasised: European households tend to increase the number of TVs in the household, and two TVs in every household in 2010 is feasible. The other reason for increased power consumption is the introduction of flat panel display (FPD) technologies, such as LCD and PDP, the higher resolution and picture quality and the increasing screen sizes. (Stobbe, 2007c)

Stobbe (2007c) recommend a two-tier approach, i.e. the industry is given two years from the time the requirements are adopted to the time they enter into force. This should give the industry enough time to develop the technology and redesign their products. Furthermore, Stobbe (2007c) recommend differentiating between High Definition (HD) ready and full HD due to the novelty of the full HD technology. (Stobbe, 2007c)

The recommendation for minimum requirements is expressed in an equation, which consists of four elements; the screen size in square inch ($a_{Screen}$) multiplied with 0.275 W/in$^2$, which is the calculated power consumption of 1 square inch screen surface area. A constant value (40W) for the power consumption of the receiver is added and finally a value ($P_{feature}$) can be added in case the TV includes additional features, for instance digital tuner or DVD/VDR.

The recommendation for tier 1 for HD ready TV is:
**PTVon, minimum req. HD-ready = $a_{Screen}$ · 1 · 0.275 W/in² + 1 · 40 W + $P_{feature}$**

Whereas the recommendation for tier 1 for full HD TV is:
**PTVon, minimum req. full HD = $a_{Screen}$ · 1.4 · 0.275 W/in² + 1 · 40 W + $P_{feature}$**

An example of how to calculate the $P_{feature}$ is given in the preparatory study (Stobbe, 2007c):

$P_{feature}$ = $n_{feature}$ (number of additional functions)* $P_{basic}$/10

where
$n_{feature}$ = 3 (DVB-S, HDR, W-LAN)
$P_{basic}$ = 40 W

<=>
$P_{feature}$ = $n_{feature}$ (3)* 40/10
$P_{feature}$ = 12 Watt

For further explanation of the equation, please see the LOT 5 preparatory studies, Task 8.

In Figure 2-1 the recommended minimum requirements for power consumption in on-mode are illustrated.

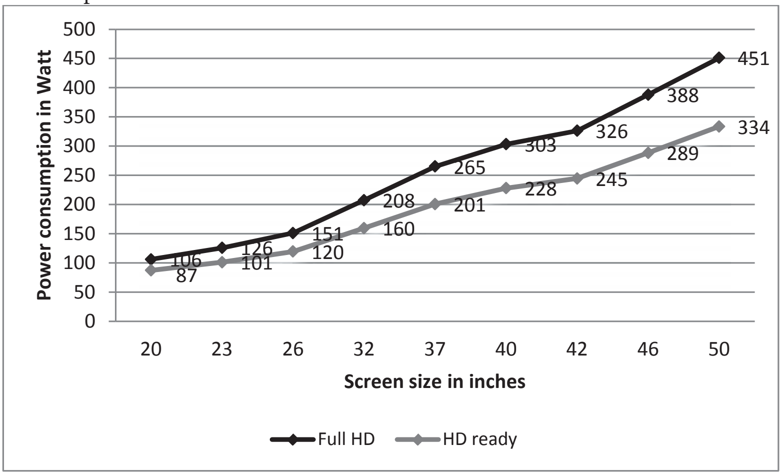



FIGURE 2-1 RECOMMENDED MINIMUM REQUIREMENTS FOR POWER CONSUMPTION IN ON-MODE BY THE PREPARATORY STUDY. BASED ON (STOBBE, 2007C).

Finally, Stobbe (2007c) recommend applying the IEC 62087[2] dynamic broadcast-content video signal test method when testing the on-mode power consumption of TVs. It is also recommended that the EIC standardization body should include the definition of a "standard mode" in which the TVs on-mode power consumption should be measured. For instance, in the current definition, the standard does not define how the contrast and brightness should be adjusted; both of which influences the power consumption in on-mode. (Stobbe, 2007c) There are no recommendations the default setting being the most energy efficient mode.

[2] IEC is the International Electrotechnical Commission (International Electrotechnical Commission, 2010)

### 2.2.2 Power Consumption in Off-mode and Standby

Stobbe (2007c) recommends setting up minimum requirements for off-mode and three types of standby. The two types of standby are: passive standby[3] and active standby low[4]. Also for these requirements a two-tier approach is recommended, where tier 1 requirements should not come into effect earlier than two years from the publication in the Official Journal, and tier 2 should come into effect two years after the tier 1 requirements come into effect. Table 2.3 lists the recommended requirements.

Table 2.3 Recommended minimum requirements for power consumption in off-mode and standby (Stobbe, 2007c p. 30-33).

| | Preparatory Study |
|---|---|
| Off-mode tier 1 | Compliance in 2010: ≤ 0,5 W |
| Off mode tier 2 | Compliance in 2012: ≤ 0,2 W |
| Off mode | Primary hard off switch (0 W) is optional |
| Passive standby tier 1 | Compliance in 2010 ≤ 1 W |
| Passive standby tier 2 | Compliance in 2012 ≤ 0,5 W |
| Active standby low tier 1 | Compliance in 2010 ≤ 3 W |
| Active standby low tier 2 | Compliance in 2012 ≤ 2 W |
| Active standby low tier 3 | Compliance in 2015 ≤ 1 W |
| | Automatic transition into active standby low after the main function ended |

### 2.2.3 Introduction of an Energy Efficiency Label

The introduction of an energy efficiency label is recommended in order to promote the best performing products, stimulate the market and give the industry further incentives to improve the energy efficiency of their products. The authors argue that the trend is towards an increase in power consumption in on-mode rather than a decrease, therefore the energy efficiency label is recommended as a supplement to the minimum requirements. (Stobbe, 2007c)

The energy efficiency label should only focus on the on-mode power consumption, and it is recommended to base the label criteria on an equation that considers the screen size similar to the equation set for the minimum requirement for power consumption in on-mode. (Stobbe, 2007c)

### 2.2.4 Chemicals

The study emphasises the importance of compliance with the RoHS Directive 2002/95/EC. Further, it is recommended that the development of new technologies should focus on reducing potentially hazardous substances in the products. However, this should not be at the expense of the energy efficiency as power consumption is the most significant environmental impact of the product. (Stobbe, 2007c)

---

[3] Passive standby is defined as: Reactivation; remote control reactiviation, self reactivation (e.g. timer), switch reactivation and continuos functions; information/status display, energy for information storage, sensor-based safety functions. (Stobbe, 2007b)

4 Active standby low is defined as: Network integrity communication (e.g. search for channels or software updates), wake-up over network (e.g. reactivation for program download recording). (Stobbe, 2007b)

Table 2.4 lists the recommended requirements for chemicals in TVs. The RoHS Directive 2002/95/EC exempts the use of mercury in certain applications. Therefore the requirements focus on information to the consumer rather than prohibition of substances. (Stobbe, 2007c)

Table 2.4 Recommended requirements for chemicals in TVs (Stobbe, 2007c: p. 40-41).

| | Preparatory Study |
|---|---|
| **Substances regulated in the RoHS Directive 2002/95/EC** | Components must comply with the RoHS Directive 2002/95/EC |
| | The cover of the Back Light Unit (BLU) should indicate the contents of mercury |
| | For PDP and CRT: As long as the execemption under RoHS is valid, it is recommended to require a declaration of the lead content in the Plasma Display |

### 2.2.5 General Eco-design Requirements

The study recommends specific eco-design requirements solely regarding chemicals in TVs – see section 1.2.4. On a more general level the study recommends that the standard ECMA 341 – *Environmental Design Considerations for ICT and CE Products* or IEC 62430 - *Environmentally conscious design for electrical and electronic product* is considered when setting general eco-design requirements. However, as the two standards focus on Information and Communication Technologies (ICT) and Consumer Electronics (CE) in general, the development of a more detailed eco-design guidance document based on the findings of the preparatory study is recommended. The guidance document could include guidance on mandatory requirements. (Stobbe, 2007c)

### 2.2.6 Green Procurement

In connection with the requirements of the RoHS Directive, the authors recommend that industry applies green procurement procedures and investigate RoHS compliance of their purchased components. (Stobbe, 2007c)

### 2.2.7 Environmental Information

The final recommendation for requirements concerns environmental information, which the industry should make available to the consumers and the recycling industry, respectively. Table 2.5 lists the information, which the industry should make available.

Table 2.5 Recommended information requirements (Stobbe, 2007c).

| Preparatory Study |
|---|
| Mandatory energy efficiency labelling |
| Mode-specific power consumption data in sales advertisements and user manuals |
| Rated power consumption in user manuals |
| Explanations of power modes and energy saving options in user manuals |
| Warning of mercury content in baclights (to the recycling industry) |

### 2.2.8 Overview of Recommended Requirements

Table 2.6 presents an overview of the recommended requirements. For clarity reasons, the detailed description of the requirements is not presented here. Instead colours indicate the areas in which the study has recommended setting requirements. The green colour illustrates primary focus of the study and the yellow colour illustrates the secondary focus.

Table 2.6 Overview of the recommended requirements

| Subject | Preparatory Study |
|---|---|
| Power consumption on-mode | |
| Power consumption in off-mode | |
| Power consumption in passive standby | |
| Power consumption active standby low | |
| Introduction of energy efficiency label | |
| General eco-design requirements | |
| Chemicals in products | |
| Green procurement | |
| Information requirements | |

The preparatory study has a strong focus on energy efficiency both in on-mode, standby and off mode see Table 2.6. The study emphasised several times that energy consumption is the most significant environmental impact, compared to the other mentioned areas.

In the process of analysing the potential requirements, Stobbe has investigated both the existing technology, and the technology assessed to be most used in the future. Therefore, the primary focus was put on the LCD and PDP technology, whereas the CRT technology has been analysed as a reference product.

However, some emergent technologies have not been given the necessary attention in the study, and these technologies have gained in importance on the market shortly after the study was completed. Especially, the LED technology used as backlight system in LCD TV's would have been relevant to analyse in depth the preparatory study, as this technology has a significant improved energy efficiency compared to PDP and traditional LCD. The OLED technology is also an energy efficient technology, which has not been investigated in depth. This technology is, however, still mostly used in small display equipment, which is not in the scope of the study.

# 3 Implementing Measures: TV

In this chapter the Implementing Measures (IM) are analysed and compared to the recommendations of the preparatory study. The aim is to investigate to what extent the IM follow the recommendations of the preparatory study.

The IM for TVs was passed as Commission Regulation (EC) No 642/2009 of 22 July 2009. The scope of the IM is TVs, including both TV monitors and TV sets. (European Commission, 2009c)

The Directive defines a TV monitor as "*a product designed to display on an integrated screen a video signal from a variety of sources, including television broadcast signals, which optionally controls and reproduces audio signals from an external source device, which is linked through standardised video signal paths including cinch (component, composite), SCART, HDMI, and future wireless standards (but excluding non-standardised video signal paths like DVI and SDI), but cannot receive and process broadcast signals*". (European Commission, 2009c, art. 2.3)

TV sets are defined as *"a product designed primarily for the display and reception of audiovisual signals which is placed on the market under one model or system designation, and which consists of (a) a display and (b) one or more tuner(s)/receiver(s) and optional additional functions for data storage and/or display such as digital versatile disc (DVD), hard disk drive (HDD) or videocassette recorder (VCR), either in a single unit combined with the display, or in one or more separate units*". (European Commission, 2009c: art. 2.2)

The focus of the IM is illustrated and compared to the recommendations of the preparatory study in Table 3.1. The green colour illustrates primary focus of the study and the yellow colour illustrates the secondary focus.

Table 3.1 Focus area of the IM compared to the focus of the preparatory study.

| Subject | Preparatory Study | Implementing Measures |
|---|---|---|
| Power consumption on-mode | | |
| Power consumption in off-mode | | |
| Power consumption in passive standby | | |
| Power consumption active standby low | | |
| Introduction of energy efficiency label | | |
| General eco-design requirements | | |
| Chemicals in products | | |
| Green procurement | | |
| Information requirements | | |

The arguments for focusing solely on power consumption are presented in the comments to the Regulation. It is emphasised that in the preparatory study it was assessed that the relevant environmental impact, for the purpose of the regulation, is the power consumption in the use phase. It is argued in the comments that environmental impacts related to hazardous substances in the TVs and waste from disposed TVs are not addressed by the regulation as this is addressed in the Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS) and Directive 2002/96/EC on waste electrical and electronic equipment (WEEE), respectively.

Furthermore, it is argued that the regulation should not benchmark best available technology, as this is addressed in Commission Decision 2009/300/EC establishing the revised ecological criteria for the award of the Community ecolabel to TVs (the European Ecolabel). In the following the requirements of the IM are elaborated.

In Article 6 of the IM a review clause is presented. The Commission must within three years of the entry into force of the IM review the regulation and here take into account the technological development. The results of the review must be presented to the Ecodesign Consultation Forum. (European Commission, 2009c)

### 3.1 Power Consumption in on-mode

As recommended in the preparatory study the IM have a multi tier approach to the implementation of the on-mode power consumption requirements. In the first tier applicable from 20th August 2010 the requirement differentiates between full HD and other resolutions, whereas all resolutions must comply with the same requirement in the second tier applicable from 1st April 2012.

The requirement consists of some of the same elements as the recommended requirement from the preparatory study; the screen size (A) is multiplied with a constant for the calculated power consumption of 1 $dm^2$ screen surface area and a constant is added. However, the requirement unit is $dm^2$ instead of square inch, and instead of adding a constant value ($P_{feature}$) as recommended in the preparatory study, the requirement differentiates between TV sets and monitors, see Table 3.2 and Table 3.3.

Table 3.2 On-mode power requirements applicable from 20 August 2010 (European Commission, 2009c: Annex 1).

| | Full HD | All other resolutions |
|---|---|---|
| TV sets | 20 W + A · 1,12 · 4,3224 W/dm2 | 20 W + A · 4,3224 W/dm 2 |
| Monitors | 15 W + A · 1,12 · 4,3224 W/dm2 | 15 W + A · 4,3224 W/dm 2 |

Table 3.3 On-mode power consumption applicable from 1 April 2012 (European Commission, 2009c: Annex 1).

| | All resolutions |
|---|---|
| TV sets | 16 W + A · 3,4579 W/dm 2 |
| Monitors | 12 W + A · 3,4579 W/dm 2 |

The on-mode power consumption requirement for TV sets is illustrated in Figure 3-1 together with the recommendations of the preparatory study.

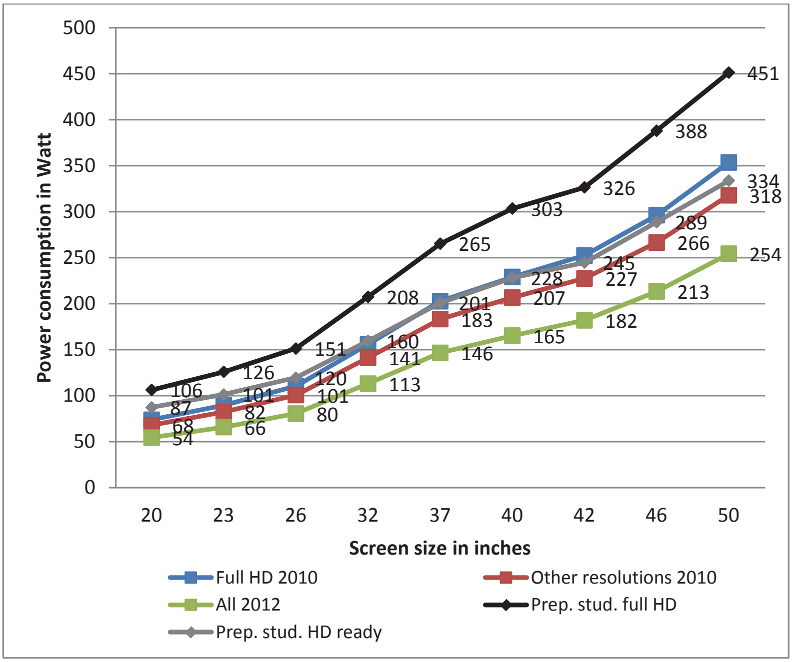



Figure 3-1 On-mode power consumption requirements compared to the recommendations of the preparatory study. Based on (Stobbe, 2007c) and 2010 (European Commission, 2009c: Annex 1).

Compared to the recommendations of the preparatory study it is clear that the IM have tightened the requirements. Taking a closer look at the equation it seems that the IM have been inspired by the ecolabels. Both the constant (20W, 15 W) and the 4.3224 W/dm$^2$ are the same as in the European Ecolabel and the Nordic Ecolabel (see Chapter 3). Comments from stakeholders wanting to lower the constant from 40W to 15-20 W have also been heard (Stobbe, 2007d).

In addition to the on-mode power requirements the IM sets requirements for TVs with a forced menu[5] and the peak luminance of the TV. Applicable from 20 August 2010; "*TVs with forced menu or initial activation of the television shall provide a "home-mode" in the forced menu, which shall be the default choice on initial activation of the television. If the user selects a mode other than "home-mode" on initial activation of the television, a second selection process shall be prompted to confirm this choice*" (European Commission, 2009c). Home-mode is the TV setting that is recommended by the manufacturer for normal home use (European Commission, 2009c).

From August 20, 2010 the following requirements are applicable regarding the peak luminance ratio (European Commission, 2009c, Annex 1):

- TVs without forced menu: the peak luminance of the on-mode condition of the TV as delivered by the manufacturer shall not be less than 65 % of the peak luminance of the brightest on-mode condition provided by the TV.

[5] Forced menu is defined as "*a set of television settings predefined by the manufacturer, of which the user of the television must select a particular setting upon initial start-up of the television*" (European Commission, 2009b).

- TVs with forced menu: the peak luminance of the home-mode condition shall not be less than 65 % of the peak luminance of the brightest on-mode condition provided by the TV.

The preparatory study recommends the use of the IEC 62087 standard on dynamic broadcast-content video signal test method for testing the on-mode power consumption. In Annex II of the Regulation the conditions for measuring on-mode power consumption, standby and peak luminace are listed. (European Commission, 2009c)

### 3.2 Power consumption in off-mode and standby

In Table 3.4 the requirements on power consumption in off-mode and standby are listed and compared to the recommendations of the preparatory study. The requirements come into force in two steps. The first requirements have been applicable since January 7 2010, and the second step will be applicable from 20 August 2011.

Table 3.4 Off-mode and standby requirements of the IM

| | Preparatory Study | Implementing Measures |
|---|---|---|
| Off-mode | Compliance in 2010: ≤ 0,5 W | Compliance in 2010: ≤ 1,00 W |
| Off mode tier 2 | Compliance in 2012: ≤ 0,2 W | Compliance in 2011:<br>≤ 0,5 W if the TV has an easily visible off switch putting the TV in off-mode using ≤ 0,01 W<br>Otherwise: ≤ 0,3 W |
| Off mode | Primary hard off switch (0 W) is optional | TVs shall have an off-mode and/or standby-mode, and/or another condition which does not exceed the applicable power consumption requirements for off-mode and/or standby-mode when the TV is connected to the mains power source. |
| Passive standby tier 1 | Compliance in 2010 ≤ 1 W | Compliance in 2010: ≤ 1,00 W<br>≤ 2,00 W if the TV is providing information or status display |
| Passive standby tier 2 | Compliance in 2012 ≤ 0,5 W | Compliance in 2011: ≤ 0,50 W<br>≤ 1,00 W if the TV is providing information or status display |
| Passive standby | | For TV sets which consist of a display, and one or more tuner(s)/receiver(s) and optional additional functions for data storage and/or display such as digital versatile disc (DVD), hard disk drive (HDD) or videocassette recorder (VCR) in one or more separate units, points (a) to (c) apply for the display and the seperate unit(s) individually |
| Active standby low tier 1 | Compliance in 2010 ≤ 3 W | |
| Active standby low tier 2 | Compliance in 2012 ≤ 2 W | |
| Active standby low tier 3 | Compliance in 2015 ≤ 1 W | |
| Automatic power down | Automatic transition into active standby low after the main function ended | Compliance in 2011:<br>After no more than 4 hours in on mode following the last user interaction and/or a channel change, the TVs shall be automatically switched from on mode to:<br>— standby-mode, or,<br>— off-mode, or,<br>— another condition which does not exceed the applicable power consumption requirements for off-mode and/or standby-mode |
| | | TVs shall display an alert message before the automatic switch from on mode to the applicable condition/modes.<br>This function shall be set as default. |
| Home-Mode | | TVs with forced menu on initial activation of the television shall provide a 'home-mode' in the forced menu, which shall be the default choice on initial activation of the TV. If the user selects a mode other than 'homemode' on initial activation of the TV, a second selection process shall be prompted to confirm this choice |

The IM are to some degree aligned with the recommendations of the study, as it appears from Table 3.4. One important difference is that the IM do not formulate specific requirements for each of the standby modes presented by the preparatory study. On the contrary, the IM defines only one standby mode. The requirement for standby is aligned with the recommended requirement for passive standby, which indicates that the standby requirements of the IM are slightly stricter than what is recommended by the study. On the other hand, the requirement set up for power consumption in off-mode is less strict than recommended.

Finally, the recommendation on an automatic power down function was followed and a requirement on a "home-mode" for TVs' with a forced menu was added.

## 3.3 Environmental Information

The requirements on Environmental Information are listed and compared to the recommendations of the preparatory study in Table 3.5

Table 3.5 Requirements on environmental information of the IM.

| Preparatory Study | Implementing Measures |
|---|---|
| Mandatory energy efficiency labelling | |
| Mode-specific power consumption data in sales advertisements and user manuals | The product's power consumption in on-mode, standby and off-mode |
| Rated power consumption in user manuals | |
| Explanations of power modes and energy saving options in user manuals | |
| Warning of mercury content in backlights (to the recycling industry) | If the product contains mercury or lead |
| | The ratio of the peak luminance of the on-mode or home-mode condition of the TV as delivered by the manufacturer and the peak luminance of the brightest on-mode condition provided by the TV, expressed in percentage, rounded to the nearest integer |

Some elements regarding the requirements on environmental information have been adopted from the recommendations. This goes for the requirements on information about the product's power consumption in on-mode, standby and off-mode, and for the information about lead and mercury in the product. There are no requirements set up for rated power consumption and an explanation of power modes and energy savings options. In connection with the requirement on peak luminance, a requirement on information about the ratio of the peak luminance has been introduced.

## 3.4 Comparison of Implementing Measures and Preparatory Study

The IM follow the recommendations of the preparatory studies rather closely in the sense that only requirements on power consumption have been set up. This was emphasised in the study to be the most significant environmental impact of TVs and the IM refers to the RoHS and WEEE Directives with regards to the requirements on chemicals, recycling and waste arguing that these issues are regulated here.

Comparing the requirements that have been set up to the recommended requirements of the preparatory study it is clear that these are inspired by the recommendations, but they have been developed further. For instance, the requirements for on-mode power consumption are tightened and the equation for calculating the requirements has been changed. The new equation seems to be inspired by the calculation method of the European Ecolabel and stakeholder comments have been taken into account. On the other hand, the requirements for off-mode power consumption are less tight and there are only set up requirements for one type of standby, compared to the two types recommended by the preparatory study. The standby requirements are though identical to the strictest of the standby requirements recommended by the preparatory study, indicating that the IM set stricter requirements on standby power consumption. Finally, with regards to power consumption the IM have set requirements to an automatic power down system and a default “home-mode” which both are functions that should lower the power consumption of the TV.

The only requirement of the IM not related to power consumption is an information requirement on the content of lead and mercury in the TV, which partly is recommended by the preparatory study.

# 4 Ecolabels and TVs

In this chapter, different ecolabels for TVs will be analysed with the aim of investigating where the ecolabels have "set the bar" on what is being considered environmentally friendly. Authorities, consumers and producers acknowledge Ecolabels; e.g. when buying an ecolabelled product the consumer can be confident that the product is among the best environmentally performing products in its product category. All ecolabels presented in this chapter, except the Energy Star consider the entire life cycle of the product. This includes aspects of the life cycle from the extraction of raw materials to the product is being disposed of or recycled and sets requirements to all relevant life cycle phases. Besides their focus on the environment, the ecolabels also ensure that the quality is not impaired. Consequently, it is relevant to investigate which environmental requirements ecolabels can set without compromising with the quality of the product.

In the following sections the ecolabels relevant for TVs will be presented. These are:

- The European Ecolabel
- The Nordic Ecolabel
- Energy Star
- TCO'06

For each label the scope and the criteria will be presented.

## 4.1 The European Ecolabel

The European ecolabel was established by the European Commission in 1992 and is used all over Europe (Ecolabelling Denmark, 2010). A wide range of products can be awarded the European Ecolabel from campsite services to paint and refrigerators. Figure 4-1 shows the European Ecolabel.

Figure 4-1 The European Ecolabel (European Commission, 2011).

The latest Commission Decision on establishing the revised ecological criteria for the award of the Community Ecolabel to TVs was made in March 2009. The decision applies from November 1, 2009 and is valid until October 31

2013. The scope of the flower is *"Mains powered electronic equipment, the primary purpose and function of which is to receive, decode and display TV transmission signals"*. (European Commission, 2009b: art. 1)

Table 4.1 lists the focus areas of the European Ecolabel compared to the focus areas of the IM. In comparison to the focus areas of the IM it is clear that the European Ecolabel has a broader focus including also other environmental issues than just power consumption. In the following each of the focus areas will be elaborated.

Table 4.1 Overview of the focus areas of the European Ecolabel.

| Subject | Implementing Measures | European Ecolabel |
|---|---|---|
| Power consumption on-mode | | |
| Power consumption in off-mode | | |
| Power consumption in standby | | |
| Maximum energy consumption | | |
| Dismantling | | |
| Life-time extension | | |
| Chemicals in products | | |
| Information requirements | | |

#### 4.1.1 Power Consumption in On-mode

A three-tier approach is chosen to the energy efficiency requirement for on-mode power consumption, where the requirements are tightened in three steps. As it appears from the below equations the European Ecolabel requirement consists of the tier 1 requirement for "other" resolutions of the IM multiplied with a constant.

For tier 1, which is valid from 1 November 2009, the following equation is the requirement:
$\mathbf{0.64 \cdot (20\ W + A\ \cdot 4.3224\ W/dm^2)}$

The requirement is gradually tightened:
Tier 2, which is valid from 1 January 2011:
$\mathbf{0.51 \cdot (20\ W + A\ \cdot 4.3224\ W/dm^2)}$

and tier 3, which is valid from 1 January 2013:
$\mathbf{0.41 \cdot (20\ W + A\ \cdot 4.3224\ W/dm^2)}$

Figure 4-2 illustrates the requirement for on-mode power consumption for the Flower.

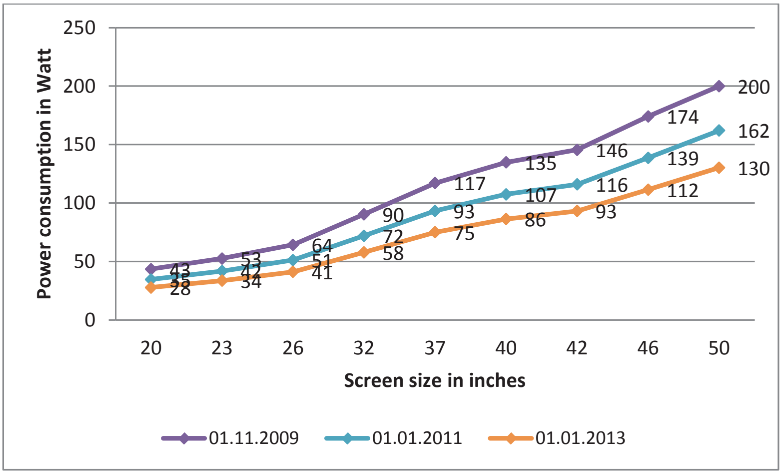



Figure 4-2 The energy efficiency requirement in on-mode for the European Ecolabel. Based on (European Commission, 2009b)

A further requirement has been set up regarding the on-mode power consumption, which is a maximum for power consumption in on-mode. This is set to a maximum of 200 W. (European Commission, 2009b)

Compared to the requirements of the IM, the European Ecolabel does not distinguish between HD ready and full HD, both technologies have to comply with the same criteria. Furthermore, the European Ecolabel sets far more strict requirements than recommended in the IM. For instance, 42" TV is in the IM 2010 required to use no more than 252 W in full HD and no more than 227 W in other solutions. If a 42" TV complies with the European Ecolabel the power consumption shall be no more than 146 W. This is around 100 W below the requirement of the IM.

### 4.1.2 Power Consumption in Off-mode and Standby

The European Ecolabel sets no specific requirements regarding off-mode power consumption. However, if the TV has an off-on switch this has an influence on the requirement for the power consumption in passive standby. If the TV has an off switch and the off-mode power consumption is less than 0.01 W, then the criteria for passive standby is $P_{standby} \lesssim 0.5$ W. For all other TV's the passive standby consumption criteria is $P_{standby} \leq\leq 0.3$ W.

Comparing the requirements of the European Ecolabel with the requirements of the IM it is clear that the standby criterion of the European Ecolabel is significantly stricter than those of the IM, see Table A.1 in Appendix A. The standby requirement is actually the same as the requirement in off-mode of the IM. This strict requirement could be the reason for that no requirements are set up for other standby or off-mode including the automatic power down, which is required by the IM.

### 4.1.3 Chemicals

Unlike the IM the European Ecolabel has strong emphasis on chemicals in the product. The European Ecolabel criteria for chemicals in TVs are listed in Table 4.2.

Table 4.2 Requirements on chemical content in product labelled with the European Ecolabel (European Commission, 2009b)

| | European Ecolabel |
|---|---|
| **Substances regulated in the RoHS Directive 2002/95/EC** | The product must comply with the RoHS Directive 2002/95/EC |
| | Mercury content in fluorescent lamps: The total, amount of mercury in all lamps, per screen, shall be no greater than 75 mg Hg for screen sizes up to 40 inches, and no greater than 99 mg Hg for screen sizes above 40 inches |
| | Plastic parts may not contain flame retardants, or preparations that are assigned or may be assigned the risk phrases: R40 (possible risk of cancer), R45(may cause cancer), R46 (may cause heritable generic damage), R50 (very toxic to aquatic organisms), R51 (toxic to aquatic organisms), R52 (harmful to aquatic organisms), R53 (may cause long term adverse effects in the aquatic environment), R60(may impair fertility) and R61 (may cause harm to unborn child), R62 (possible risk of impaired fertility), R63 (possible risk of harm to the unborn child) |

As mentioned, the IM sets no requirements on chemical content of products, as the IM refers to the RoHS and WEEE Directive for these types of requirements. This is in contrast to the European Ecolabel, which sets very specific requirements regarding chemical content in TVs. In this way the European Ecolabel clearly demonstrate its comprehensive life cycle focus.

#### 4.1.4 General Eco-design Requirements

Apart from the criteria on energy efficiency and chemicals, the European Ecolabel sets up general eco-design criteria within the two areas, see Table 4.3. The aim of the dismantling requirement is to be able to repair and replace worn-out parts, upgrade older or obsolete parts, and finally to separate different materials for recycling.

The following points should be considered in this respect (European Commission, 2009b):

- Fixtures within the products shall allow for this disassembly, e.g. screws, snap fixes, especially of parts containing hazardous substances
- Plastic parts shall be of one polymer or be of compatible polymers for recycling and have the relevant ISO 11469 marking if greater than 25g in mass
- Metal inlays that cannot be separated shall not be used
- Data on the nature and amount of hazardous substances in the TV will be gathered in accordance with the Dangerous Substances Directive 67/548/EEC and its subsequent amendments and the Globally Harmonised System of Classification and Labelling of Chemicals (GHS)

Table 4.3 General ecodesign requirements of the European Ecolabel (European Commission, 2009b)

| | European Ecolabel |
|---|---|
| **Dismant-ling** | The manufacturer shall demonstrate that the product can be easily dismantled by professional recyclers |
| **Life-time extension** | The manufacturer shall offer a commercial guarantee to ensure that the product will function for the least two years |
| | The availability of compatible electronic replacement parts shall be guaranteed for seven years from the time the production ceases |

Comparing the European Ecolabel criteria with the requirements of the IM, the European Ecolabel looks more holistically on environmental impacts of a TV. Where the preparatory study slightly touches upon ecodesign, the IM have completely left this part out of the requirement setting. The European Ecolabel, on the other hand, sets specific requirements that help prolong the lifetime of the product and ease the dismantling and recyclability of the TV.

### 4.1.5 Environmental Information

The final type of criteria that the European Ecolabel sets up concern information to the end user and recyclers. In general, the requirement states that the product must be sold with information about the product's proper environmental use. This information must be available in the instructions where it is easy to find and also the webpage of the producer. (European Commission, 2009b) Table 4.4 lists the information requirements compared to the information requirements of the IM.

Table 4.4 General information requirements of the European Ecolabel (European Commission, 2009b)

| Implementing Measures | European Ecolabel |
|---|---|
| | Information that the product has been awarded the flower |
| The product's power consumption in on-mode, standby and off-mode | The product's power consumption information in various modes; on, off and passive standby, including information on energy savings possible in different modes |
| | Explanations of how to reduce power consumption when the product is not being used |
| If the product contains mercury or lead | |
| The ratio of the peak luminance of the on-mode or home-mode condition of the TV as delivered by the manufacturer and the peak luminance of the brightest on-mode condition provided by the TV, expressed in percentage, rounded to the nearest integer | |

Some requirements regarding environmental information are overlapping (see Table 4.4). However, the European Ecolabel has a stronger focus on how the consumer can reduce the power consumption of the TV.

### 4.1.6 Discussion of the European Ecolabel Criteria

In the above sections the European Ecolabel criteria are presented and compared to the requirements of the IM. Briefly summing up on the analysis, the European Ecolabel differentiates from the IM on the following points:

- Equal focus on all environmental requirements
- Stricter requirements on energy efficiency
- Stricter requirements on chemical content
- Specific ecodesign requirements to improve dismantling and prolong life-time of the product
- More information to the consumer on his/her responsibility

The European Ecolabel looks more comprehensively on all environmental impacts of TVs than the IM; in general the requirements are stricter with respect to energy efficiency, chemicals, ecodesign and environmental information. With regard to the environmental information there are overlapping requirements, but the European Ecolabel focuses more on the responsibility of the consumer. It could be argued though that the IM have set requirements for automatic power down that reduces the need for consumer awareness as the product on its own turns off after while with no user interaction. On the one hand, one can be sure of energy reduction, but on the other hand the learning element for the consumer, where he needs to think about his actions, is missing in the IM.

### 4.2 The Nordic Ecolabel

The Nordic Council of Ministers established the Nordic Ecolabel in 1989. The label is primarily directed towards the Nordic market; Denmark, Norway, Sweden, Finland and Iceland. The Nordic Ecolabel is, to a wide extent, harmonised with the European Ecolabel, which means that if a product already has been awarded the European Ecolabel only a few extra criteria must be fulfilled in order to obtain the Nordic Ecolabel. The European Ecolabel was developed after the Nordic Ecolabel, with the aim of gathering all national ecolabels in one. Therefore there are not many differences between the labels. The reason for there still being two labels is partly practical, as still more product groups can be labelled with the Nordic Ecolabel than with the European Ecolabel. (Ecolabelling Denmark, 2010)

A wide range of product groups can be awarded the ecolabel, such as shampoo, toilet paper and TVs. Figure 4-3 shows the Nordic Ecolabel.

Figure 4-3 The Nordic Ecolabel (Ecolabelling Denmark, 2010).

The newest criteria for Audiovisual equipment (Version 4.0) are valid in the period December 15 2009 – December 31 2013. The following product groups, within the scope of the Nordic Ecolabel for Audiovisual equipment, are relevant for this report: TVs and TVs in combination with other equipment, for instance DVD and Blue-ray players. Appliances powered by batteries and equipment with CRT displays are excluded from the scope. (Nordic Ecolabelling, 2009)

The focus areas of the Nordic Ecolabel are the same as the focus areas of the European Ecolabel, with one addition; power consumption in off-mode, see Table 4.1. In the following, each of the areas will be elaborated.

### 4.2.1 Power Consumption in on-mode

The requirement for on-mode power consumption is completely aligned with the European Ecolabel requirements for 01.01.2011 and 01.01.2013 (see Figure 4-2). Also the maximum power consumption is aligned with the European Ecolabel, i.e. that the product must have an absolute maximum power consumption of no more than 200 W. As the European Ecolabel, the Nordic ecolabel does not distinguish between HD ready and full HD, but both technologies must comply with the same criteria. Compared to the IM the allowed power consumption is significantly lower no matter the screen size.

### 4.2.2 Power Consumption in Off-mode and Standby

The requirements for power consumption in standby are identical to the requirements of the European Ecolabel, namely: if the TV has an off switch and the off-mode power consumption is less than 0.01 W, then the criteria for passive standby is $P_{standby} \leqq 0.5$ W. For all other TV's the passive standby consumption criteria is $P_{standby} \leq\leq 0.3$ W.The Nordic ecolabel does, however, set one further requirement i.e. that TV sets must have a clearly visible on-off switch.

As is the case for the European Ecolabel, the requirements of the Nordic Ecolabel are significantly stricter than the requirements of the IM, see Table A.1 in Appendix A. The criterion on a visible on-off switch is added compared to the European Ecolabel, but this was actually a requirement in the recent outdated the European Ecolabel criteria (European Commission, 2002).

### 4.2.3 Chemicals

Several criteria have been set up regarding the chemical content of the products awarded the Nordic Ecolabel. The criteria are similar to the chemical criteria of the European Ecolabel with a few execptions. The Nordic Ecolabel does not allow any mercury content in the background lighting of TVs, and does not allow the use of chlorinated paraffin. The European Ecolabel has stricter requirements towards plastic parts containing flame-retardants with certain risk phrases.

Comparing the criteria to the IM it is clear that the Nordic Ecolabel has a holistic view and includes requirements on the chemical content of TVs. In Table A.2 in Appendix A the chemical requirements of The Nordic Ecolabel are compared to the other ecolabels.

### 4.2.4 General Eco-design Requirements

Apart from the criteria on energy efficiency and chemicals The Nordic Ecolabel sets up general eco-design criteria in the following areas:

- Dismantling

- Lifetime extension

The criteria are completely aligned with the requirements of the Flower, see section 3.1.4.

As the ecodesign criteria are completely identical with the European Ecolabel, the Nordic Ecolabel takes a broader approach to a TVs environmental impact than the IM. Where the preparatory study slightly touches upon ecodesign, and the IM completely leaves this issue out, the Nordic Ecolabel sets concrete requirements that help prolong the life-time of the product and ease the dismantling and recyclability of the TV. In Table A.3 in Appendix A the general eco-design requirements of the ecolabels are compared to each other.

#### 4.2.5 Environmental Information

As in the European Ecolabel requirements the Nordic Ecolabel also sets requirements on information to the end user and the recycler. The requirements are to a large extent aligned with the requirements of the European Ecolabel. The Nordic Ecolabel does, however, not set requirements on information about possible energy savings in different modes, that energy efficiency cuts energy consumption and hence saves money on the electricity bill and the position of the hard-off switch, as does the European Ecolabel.

There is a convergence between the two ecolabels and also to some degree with the requirements of the IM, although the European Ecolabel sets stricter requirements, see Table A.4 in Appendix A. Compared to the IM, the Nordic Ecolabel has a stronger focus on how the consumer can reduce the power consumption of the TV, and information on issues that helps prolong the lifetime of the TV and improve the recyclability of the TV.

#### 4.2.6 Discussion of the Nordic Ecolabel Criteria

In the above sections the Nordic Ecolabel criteria are presented and compared to the requirements of the IM. As the Nordic Ecolabel to a large degree is aligned with the European Ecolabel, it differentiates in the same way from the IM, see Section 4.1.6.

### 4.3 Energy Star

The Energy Star is a voluntary program established by the U.S. Environmental Protection Agency and the U.S. Department of Energy in 1992. As the name indicates, the label focuses on the energy efficiency of products. The first products to be labelled where personal computers and monitors and gradually the product range of the label has expanded. Since 1998, TVs can be labelled with the Energy Star (Energy Star).

Figure 4-4 The Energy Star label (Energy Star)

In September 2009, the revision of the Energy Star specifications for TVs was finalised. Both a version 4.0 and a version 5.0 were adopted. Version 4.0 is effective from May 2010 and Version 5.0 will be effective from May 2012. The scope of the Energy star is defined as: *"Any TV, TV combination Unit* [6]*or Component Television Unit* [7] *that is marketed to the consumer as such (i.e., focusing on television as the primary function […], and is capable of being powered from either a wall outlet or a battery unit that is sold with an external power supply"*. (Energy Star, 2009: p. 4)

Table 4.5 lists the focus areas of the Energy Star programme compared to the requirements of the IM. In the following each of the areas will be elaborated.

Table 4.5 Overview of the focus areas of the Energy Star

| Subject | Implementing Measures | Energy Star ver. 4.0 and 5.0 |
|---|---|---|
| Power consumption on-mode | | |
| Power consumption in off-mode | | |
| Power consumption in passive standby | | |
| Power consumption active standby low | | |
| Maximum energy consumption | | |
| Information requirements | | |

### 4.3.1 Power Consumption in On-mode

The requirements for on-mode power consumption of the Energy Star are expressed in an equation, which takes the screen size into consideration – as in all other cases.

Table 4.6 shows the maximum on-mode power consumption and Figure 4-5 illustrates the requirement for the different screen sizes.

Table 4.6 Requirement on maximum power consumption in on-mode for Energy Star (Energy Star, 2009)

| | Screen Area | Maximum on-mode power consumption |
|---|---|---|
| **Version 4.0** | $A < 275$ square inches | $PMax = 0.190*A + 5$ |
| | $A \geq 275$ square inches | $PMax = 0.120*A + 25$ |
| **Version 5.0** | $A < 275$ square inches | $PMax = 0.130*A + 5$ |
| | $275 \leq A \leq 1068$ square inches | $PMax = 0.084*A + 18$ |
| | $A > 1068$ square inches | $PMax = 108$ |

[6] TV Combination Unit is defined as: *"A television system in which the TV and an additional device(s) (e.g., DVD player, Blu-ray Disc player, Hard Disk Drive [HDD], VCR, etc.) are combined into a single unit and which meets all of the following criteria: the additional device(s) is included in the television casing; it is not possible to measure the power requirements of the two (or more) components separately without removal of the television casing; and the system is connected to the wall outlet through a single power cable."* [ES criteria]

[7] Component Television Unit is defined as: *"A television system composed of two or more separate components (e.g., display device and tuner) marketed and sold as a television under one model or system designation. The system may have more than one power cord. The total power consumption of all components in the system is considered for purposes of ENERGY STAR qualification."* [ES criteria]

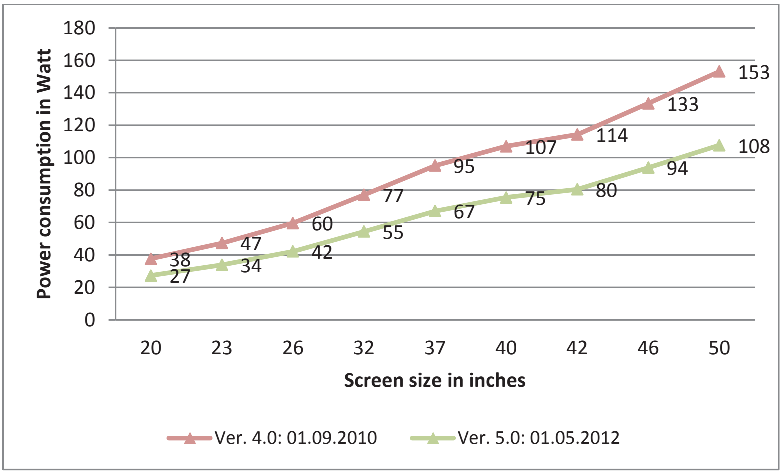



FIGURE 4-5 REQUIREMENTS FOR MAXIMUM POWER CONSUMPTION IN ON-MODE OF THE ENERGY STAR PROGRAMME. BASED ON (ENERGY STAR, 2009)

As an extra requirement the Energy Star has set up special requirements for TVs with Automatic Brightness Control (ABC). TVs with this function have a reduced power consumption compared to other TVs and this is taken into consideration in the requirement:

$$\mathbf{P}_{a1\_broadcast} = (0.55 \cdot \mathbf{P}_{o\_broadcast}) + (0.45 \cdot \mathbf{P}_{abc\_broadcast})$$

The Energy Star defines the elements of the equation as the following (Energy Star, 2009: p. 6):

*$P_{a1\_broadcast}$ is the average on-mode power consumption in watts rounded to nearest whole number, taking into consideration that the TV will be in low ambient light level conditions 45% of the time.*

- *$P_{o\_broadcast}$ is the average On Mode power consumption in watts and rounded to the nearest whole number, and tested with a minimum ambient light level of 300 lux entering directly into the sensor.*
- *$P_{abc}$_broadcast is the average On Mode power consumption in watts and rounded to the nearest whole number, with an ambient light level of zero (0) lux measured at the face of the sensor.*

As a further requirement the Energy Star specifies that the peak luminance of the TV, when in default mode, must not be less than 65% of the retail-mode, which is the brightest possible mode of the TV (Energy Star, 2009)

Comparing the Energy Star requirements with the IM, the Energy Star requirements are significantly stricter. The requirement for on-mode power consumption is almost 50% lower and in some cases even stricter. The requirement is even stricter than the other ecolabels, except the tier 2 and 3 of the European Ecolabel. The Energy Star does not distinguish between full HD and HD ready, as does the IM in tier 1, 2010.

The Energy Star does take into account the new technology with automatic brightness control, where the average on-mode power consumption should be calculated, under the condition that the TV is in low ambient light level in 45 % of the time. As the European Ecolabel and the Nordic Ecolabel, the Energy Star sets a maximum requirement on energy consumption in the 5.0

version. This is 108 Watt, which is significantly lower than the maximum of 200 Watt by the other ecolabels. The Energy Star also sets a requirement on peak luminance, which is identical to the requirement of the IM on peak luminance.

### 4.3.2 Power Consumption in Off-mode and Standby

The Energy Star sets no requirements for power consumption in off mode. Standby mode is in Energy Star is called Sleep mode. Products awarded the Energy Star must consume no more than 1 Watt in sleep mode and this goes for both Version 4.0 and 5.0. Furthermore, the manufacturer must set the lowest power consumption in sleep mode to default mode of the product. (Energy Star, 2009)

The Energy Star has defined a further mode; the Download Acquisition Mode (DAM), which to some degree is comparable to the active standby defined in the preparatory study. DAM is a mode the TV automatically switches to when communication through network, for instance updating channel listing information (Energy Star, 2009). If the TV has a DAM function the TV is allowed additional power consumption. The maximum additional power consumption is from 01.05 2010: ≤0.08 kWh/day and from 01.05 2012: ≤0.02 kWh/day.

Unlike the IM the Energy Star differentiates between active and passive[8] standby. The requirement for sleep mode is identical to the standby requirement of the IM, and in active standby the TV is even allowed to use slightly more power. Compared to the IM the Energy Star include less strict requirements, which is also underlined by the fact that no requirements are set for of-mode and automatic power down. In Table A.1 in Appendix the standby and off-mode requirements are compared to the IM and other ecolabels.

### 4.3.3 Environmental Information

The Energy Star emphasises the importance of the consumers' awareness of the impact and benefits of keeping the TV in the default modes. Hence, the Energy Star requires manufacturers to sell the Energy Star awarded products together with information about the Energy Star and an insert about the benefits of keeping the product in the default mode and information about the fact that enabling different features may increase the power consumption of the product. (Energy Star, 2009)

The requirements for environmental information in the Energy Star label focus on what the consumer can do to reduce power consumption, but it does not inform on the power consumption of the product. Again the focus on energy is obvious. See Table A.4 in Appendix A for a comparison with IM and other ecolabels.

### 4.3.4 Discussion of the Energy Star Criteria

In the above sections the Energy Star criteria are presented and compared to the IM. Different, from the other ecolabels presented, Energy Star focuses exclusively on energy efficiency. The main points of the Energy Star compared to the IM are the following:

---

[8] Passive standby is termed sleep mode in the Energy Star requirements.

- Focuses only on energy efficiency
- Stricter requirements on energy efficiency in on-mode
- Less strict requirements on standby and off mode

The only focus of the label is energy efficiency, which fits well with the scope of the IM. However, the requirements on on-mode power consumption are significantly stricter than what is recommended in the IM. On the other hand, the standby power consumption seemed to be less strict as no requirements are set for off-mode and the standby requirement is higher in 2010, and for active standby the TV may consume slightly more power.

### 4.4 TCO'06

TCO is short for Tjänstemännens Centralorganisation (the Swedish Confederation of Professional Employees) and was originally founded in Sweden (TCO Development). The first labelling program was established in 1992 and since then the program has grown to cover many different product groups (Rudling and Nordin, 2006).

A specific TCO label for TVs does not exist, but the label for media displays covers some TVs, which is why the label is found relevant in this report. The scope of the TCO'06 Media Display label is *a Flat Panel TV or a multifunction display intended to be used for e.g. monitoring or in other ways render moving images* (Rudling and Nordin, 2006). Figure 4-6 illustrates the TCO'06 label for media displays.

Figure 4-6 The TCO'06 label for media displays (TCO Development)

The latest criteria document for media displays dates back to August 2006. The TCO label includes many different areas, such as visual ergonomics, emissions from electric and magnetic fields, electrical safety, ecology and energy. However, in this study only the areas ecology and energy will be examined. Table 4.7 lists the focus areas of the TCO'06 label marked with green colour, compared to the focus areas of the IM. In the following each of the focus areas will be elaborated.

Table 4.7 Overview of the focus areas of the TCO'06 label for media displays

| Subject | Implementing Measures | TCO'06 |
|---|---|---|
| Power consumption on-mode | | |
| Power consumption in off-mode | | |
| Power consumption in passive standby | | |
| General eco-design requirements | | |
| Dismantling | | |
| Chemicals in products | | |
| Information requirements | | |
| Environmental Management system | | |

### 4.4.1 Power Consumption in Off-mode and Standby

The TCO label only set requirement for power consumption in standby, which is ≤ 1W. Standby mode is defined by the TCO label as *"the power being used when the product is connected to a power source, but produces neither sound nor picture, does not transmit nor receive program information and/or data (excluding data transmitted to change the unit's condition from "standby mode" to "active mode"), and is waiting to be switched to "on" (active/play mode) by a direct or indirect signal from the consumer, e.g. with the remote control."* (Rudling and Nordin, 2006: p.43)

The requirement on standby consumption is identical to the requirement of the Energy Star, and comparing to the IM the requirement on standby is on the same level as the standby requirement in 2010. As was the case with the Energy Star no requirements are set for off-mode and automatic power down, and there is no second tier on standby tightening the requirements. This all indicates that the TCO'06 requirement on standby is slightly less strict than the IM, see Table A.1 in Appendix A.

### 4.4.2 Chemicals

The TCO label encompasses several requirements on chemicals in the product. These are to a high degree aligned with the requirements from the EU RoHS Directive, but additional requirements have been set up. Table 4.8 lists these criteria.

Table 4.8 Requirements on chemicals in the products labelled with the TCO label. (Rudling and Nordin, 2006)

| | TCO'06 |
|---|---|
| Substances regulated in the RoHS Directive 2002/95/EC | Components must comply with the RoHS Directive 2002/95/EC and its amendments. Excempted are mercury in background lighting systems and PBB and PBDE in printed wiring boards |
| | decaBDE is not allowed even if EU has decided to excempt it from the RoHS Directive 2002/95/EC |
| Other flame retardants | Plastic parts weighing more than 25 g. shall not contain flame retardants that contain bromine or chlorine. Printed Wiring Boards are excempted. |
| | The material specifications shall be provided for plastic parts and PWB laminates that weigh more than 25 grams and which have flame retardant concentrations above 0.5 percent by weight. |
| Batteries | Limit values per listed part:<br>Mercury = 2ppm<br>Cadmium = 5 ppm<br>Lead = 50 ppm |

Compared to the IM the TCO’06 label has a strong focus on chemical content in the product, which even includes requirements for batteries, see Table A.2 in Appendix A. Emphasis is put on RoHS compliance, though with an exemption on mercury content in backlighting systems. It even forbids the use of decaBDE completely, even though this has been exempted from the RoHS directive.

### 4.4.3 General Eco-design Requirements

Besides the requirements on chemicals and power consumption the TCO label sets up quite a few requirements on the dismantling of the product. As the European Ecolabel and the Nordic Ecolabel, the TCO label requires that FPD must be easy to disassemble. See Table A.3 in Appendix for further ecodesign requirements.

Compared to the IM the TCO’06 has a strong emphasis on design for disassembly, but it does not take into consideration requirements to prolong the lifetime of the product, as does the Nordic Ecolabel and the European Ecolabel.

### 4.4.4 Environmental Information

With regards to environmental information to consumers, the TCO label primarily focuses on a proper disposal of the large amounts of electronic waste, wherefore the producers must inform the consumer of the proper disposal of the product. This should be done in the form of a product declaration for the FDP and in the user’s manual information on the possibility to dispose of the FDP by environmentally acceptable recycling should be provided.

The environmental information requirements of the TCO’06 label are very different from the requirements of the IM. The focus here is on a product declaration, and on disposal of the product. There is neither focus on power consumption nor energy efficiency; see Table A.4 in Appendix A.

#### 4.4.5 Environmental Management System

For the plants manufacturing flat panel displays the TCO'06 label requires these factories to have implemented an environmental management system, either by an ISO 14001 certification or an EMAS registration (Rudling and Nordin, 2006).

Compared to both the IM and the other ecolabels this is a new requirement.

#### 4.4.6 Discussion of the TCO'06 label

In the above sections the TCO'06 label criteria are presented and compared to the IM. The main differences from the IM are the following:

- Energy consumption: focuses solely on power consumption in standby
- Strong focus on chemicals
- Detailed requirements on dismantling properties
- Requires a certified Environmental management system

As the European Ecolabel and the Nordic Ecolabel, the TCO'06 label focuses more holistically on the environmental impact of TV and there is equal focus on all criteria. In general the requirements set up are stricter than the requirements of the IM, which is the case for energy efficiency, chemicals, ecodesign and environmental information. With regards to energy consumption though, the requirements are not as detailed and many as in the IM and other ecolabels.

### 4.5 Comparison of the Implementing Measures and the Ecolabels

In this section, the requirements of the IM and the ecolabels are compared to each other. In Table 4.9 the focus areas of the IM and the ecolabels are listed. The narrow focus of the IM on energy consumption in the use phase becomes very clear.

For a more detailed comparison on the requirements in each focus area see Appendix A.

TABLE 4.9 COMPARISON OF FOCUS AREAS OF THE IM AND ECOLABELS.

| Subject | Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star | TCO'06 |
|---|---|---|---|---|---|
| Power consumption on-mode | | | | | |
| Power consumption in off-mode | | | | | |
| consumption in passive | | | | | |
| Power consumption | | | | | |
| Maximum energy | | | | | |
| General eco-design | | | | | |
| Dismantling | | | | | |
| Life-time | | | | | |
| Chemicals in products | | | | | |
| Information requirements | | | | | |
| Environmental Management system | | | | | |

A closer look at the energy requirements on on-mode power consumption of the IM and the ecolabels is illustrated in Figure 4-7. As expected due to the role of the different policy instruments, the requirements of the IM are not as strict as the requirements of the ecolabels.

Furthermore, it should be noted that the IM do not challenge the dilemma of the direct relation between power consumption and screen size, i.e. the bigger screen sizes the higher the power consumption. With the trend of increasing screen sizes, the EuP Directive might not reduce the power consumption in on-mode, but just keep it in a steady level. This has been considered by the European and the Nordic ecolabel and the Energy Star, which all have set a maximum level for power consumption in on-mode regardless of screen size.

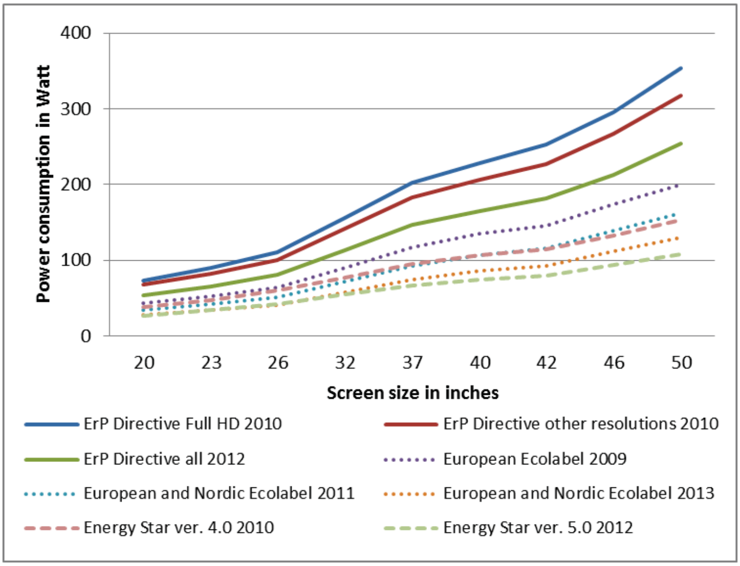



Figure 4-7 Comparison of on-mode power consumption. Based on (Eurpean Commission, 2009c: Annex 1), (European Commission, 2009b) and (Energy Star, 2009)

# 5 Performance of TVs on the Market

Existing and recommended environmental criteria for TVs were analysed in the earlier chapters. This chapter analyses what TV technologies actually exist on the market and to what extent they can fulfil the requirements of the IM and the different labels.

## 5.1 Methodology

The analysis presented in this chapter was performed in two steps. The first analysis was performed in the winter 2009/2010, approximately six months before the requirements stepped into force. The second analysis was performed in spring 2011, approximately six months after the requirements entered into force. This approach was taken firstly, to analyse the level of ambition of the EuP Directive and the Implementing Measures and secondly, to be able to assess how fast the technological innovation is.

Two groups of TVs are analysed. These are TVs with an ecolabel and TVs without an ecolabel. The TVs with an ecolabel are assessed to include Best Available Technolgies (BAT) and hence it is the assumption that these TVs have few or no problems in complying with the requirements from the IM and different labels. The analysis of TVs with an ecolabel aims at pointing out what the actual potentials are in terms of lowering the environmental impact of TVs. The TVs without an ecolabel are expected to have most difficulties complying with the requirements of the IM and the different labels. These TVs are analysed to find out what the potentials are for the IM to expel products from the market.

The TV brands analysed are presented in Section 5.2 and 5.3. The analysis of the performance of the TVs has been performed as desk research. This imples that all information used in the analysis is found on the homepages of the TV manafacturers.

## 5.2 Currently Avalable TVs with an Ecolabel

In this section TVs with an ecolabel, which are assessed to include BAT, are analysed. When investigating the market three types of technologies are continuously pointed out as the new environmental friendly technologies (see for example Philips Electronics N.V, 2009; Samsung Electronics Nordic AB, n.d and Sony, 2010). These technologies are LED (Light Emitting Diode), OLED (Organic Light Emitting Diode) and HCFL (Hot Cathode Fluorescent Lamp). The three technologies will briefly be described below.

### 5.2.1 LED and OLED Technologies

The LED technology is used in the backlight system of LCD TVs. This implies that the TV display still is a traditional LCD panel. The environmental benefit of LED technology is first and foremost the reduced energy consumption. Traditionally, LCD displays uses CCFL (Cold Cathode Fluorescent Lamps), which, besides light, also can emit heat. As the LED technology generates so called “cold” light, where no energy is wasted on production of heat the energy saving potential is according to Samsung up to

40 % (Samsung Electronics Nordic AB, n.d.). Further positive aspects of the LED technology are the long lifetime – up to 50.000 hours, and that no mercury is used in contrast to the CCFL being replaced (Philips Electronics N.V, 2009; Samsung Electronics Nordic AB, n.d.).

The OLED technology consists of organic material i.e. layers of plastic (Bush, 2009). When current runs through an OLED display, each OLED emits light on its own, without the need of a back light system (Bush, 2009). This is an advantage both in terms of reduced power consumption and reduced material use, as the display is much thinner and lighter than a typical LCD display (Freudenrich, 2005).

Even though OLED appears to have clear advantages, the technology still needs further development on certain points. To produce different colours, manufacturers place several organic films on the same OLED, where each film produces a different colour. For the blue organic film the lifetime of the OLED is substantially reduced (around 14,000 hours) compared to the lifetime of the red and the green OLED (46,000 to 230,000 hours) (Freudenrich, 2005). Furthermore, the technology is very sensitive to moisture, which reduces the lifetime even further (Bush, 2009). Finally, the size of the OLED displays should be mentioned. The technology is often used in small screen devices, such as digital cameras and cell phones. The largest available screen size in 2010 appears to be 11", produced by Sony.

The HCFL technology is used as backlight system in among others Sony Bravia TVs. With this technology Sony has been able to reduce the energy consumption with up 50 % compared to LCD displays with traditional CCFL backlight technology. (Sony, 2010)

In the 2011 analysis a new technology seems to have gained ground – the 3D technology. Samsung launched the very first 3D TFT-LCD (Thin film transistor liquid crystal display) monitor in 1999 (Samsung, 2011a). This technology displays the images in 3-dimentional fields. Since, many other TV manufacturers have 3D TVs in their product portfolio, for example Panasonic, LG and Sony (Panasonic Europe Ltd, 2010; LG, 2010 and Sony 2011). In this analysis only 3D televisions from Samsung have been analysed.

After this brief introduction of the technologies, some of the available products will be analysed in the following sections.

### 5.2.2 Samsung

In 2007, Samsung launched its first LED based LCD TV (Samsung, n.d.). In 2009/2010 three series of ecolabelled LCD TVs are available based on the LED technology. These are Samsung LED TV series 8 (available in 40" and 46"), series 7 (available in 32", 40", 46" and 55") and series 6 (available in 32", 40" and 46"). All three series have been awarded the Nordic Ecolabel and the European Ecolabel (Samsung Electronics Nordic AB, n.d.).

In May 2011, the series 6, 7 and 8 included televisions that were labelled with the European Ecolabel. However, the power consumption was stated only for the series 6 and 8 and only for the screen sizes 32" and 40". This is reflected in Figure 5.1. All presented TVs are with the LED technology and 3D technology. In the 40" TV from the 8 series Samsung has introduced an Eco sensor, which is a sensor that measures the light in the room and automatically adjusts the backlight accordingly. This feature provides a better picture quality and saves energy. (Samsung, 2011)

In the following sections Samsungs LED TVs are compared to the ecolabel requirements and the IM. The complete overview of the comparison is presented in section 5.2.5 and Appendix B, whereas more overall comments to the comparison are given in the following sections.

*Power Consumption in On-mode*

As mentioned, LCD TVs based on LED technology has an advantage in terms of energy efficiency. This becomes clear when looking at the power consumption in on-mode, see Figure 5-1.

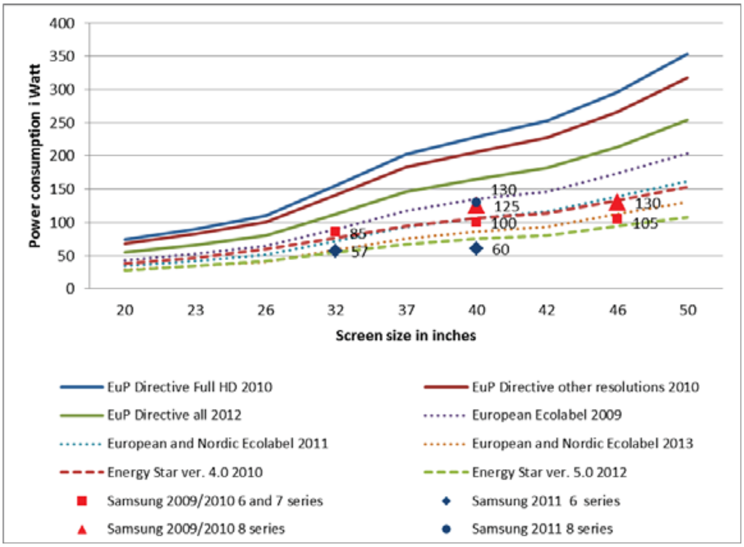



Figure 5-1 Power consumption of Samsung's LED TVs, compared to the requirements of different ecolabels and IM. (Samsung Electronics Nordic AB, n.d.; Samsung, 2011)

All Samsung TVs can easily comply with the IM, the European Ecolabel and the Nordic Ecolabel, as shown in Figure 5-1. The Samsung Series 6 and 7 40" and 46 can even comply with the Energy Star 4.0 and tier 2 of the Flower criteria. The 46" also complies with tier 3 of the Flower criteria. All LED TVs can comply with the requirement of the European Ecolabel and the Nordic Ecolabel of a maximum energy consumption of 200 W. Even with the new 3D technology the 2011 32" TV of the 6 series can comply with the European Ecolabel 2013 and the 40" can comply with even the strictest requirements.

*Power Consumption in Off-mode and Standby*

As in the case of on-mode power consumption, the standby consumption is also low and the TVs do comply with all four ecolabels and recommendations from the preparatory study with regards to passive standby. It has however not been possible to find information on all power consumption categories. Table B1 in Appendix B summarises Samsung's LED TV Series 6, 7 and 8 performances on standby and off-mode power consumption

*Chemicals*
Due to the use of LED technology instead of fluorescent lights it has been possible for Samsung to eliminate the use of mercury. In Table B.2 in Appendix B the performance of Samsung's LED TVs on chemicals is compared to ecolabels and the requirements of the IM.

*General Eco-design Requirements*
It has been difficult to obtain all relevant information to determine Samsung's LED TVs compliance with the different ecolabels. However, as the TVs have been awarded the Nordic Ecolabel in 2009/2010 and the European Ecolabel in 2011 it is assumed that the requirements are met even though no information has been available for this study. Table B.3 in Appendix B summarises the compliance of Samsung's LED TVs with the ecolabels and the requirements of the IM.

*Environmental Information*
Data on environmental information to the consumer has been obtained though studying the user manuals of the TVs and studying the web pages of Samsung. In Table B.4 in Appendix Samsung's compliance with ecolabels and the IM is presented.

### 5.2.3 Sony

Sony produces several TV models, where Sony Bravia WE5 models are promoted as especially environmental friendly. The models Sony Bravia KDL 40WE5W and KDL 46WE5W (available in 40" and 46" respectively) are in 2010 awarded the European Ecolabel (Sony, 2010).

In January 2011, an analysis of Sonys TV portfolio was performed again and the analysis showed that the ecolabelled TVs performed worse in terms of power consumption than other Sony TVs. Hence in the analysis of BAT 2011 the TVs presented are not ecolabelled. The TVs investigated are KDL-40EX700 and KDL-46EX710 (available in 40" and 46"). (Sony, 2011)

In the following sections Sony's TVs will be compared to the ecolabel requirements and the IM. The complete overview of the comparison is presented in section 5.2.5, whereas more overall comments to the comparison are given in the below sections.

*Power Consumption in on-mode*
Sony Bravia is a LCD TV, which uses energy efficient backlight technology: micro-tubular Hot Cathode Fluorescent Lamp (HCFL). With this technology it has been possible to reduce power consumption with 50% compared to previous Bravia TVs (Sony, 2010).

Besides the energy efficient backlight technology, a number of features are installed that helps to reduce the power consumption even further. An intelligent presence censor detects body heat and movement in front of the TV, so if you leave the room the TV turns off the picture and only the sound is left on. The picture comes back when the presence censor detects movements again or it switches to standby if no movement has been registered in a longer period. A light censor registers the light in the room and adjusts the backlight accordingly to achieve highest energy efficiency. (Sony, 2010)

Sony Bravia has two modes; Shop mode and Home mode. In Shop mode the TV uses 38-46% more power in on-mode compared to Home mode depending on the screen size. Figure 5-2 illustrates the on-mode power consumption of Sony Bravia in Home mode.

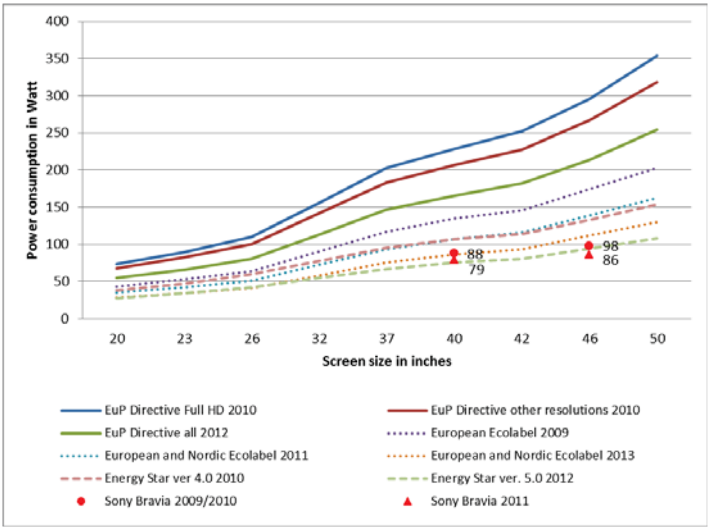



Figure 5-2 Sony Bravia power consumption in on-mode compared to ecolabels and the requirements of the IM (Sony, 2010; Sony, 2011).

*Power Consumption in Off-mode and Standby*

Sony Bravia performs very well when it comes to standby and off-mode power consumption. The TVs analysed in 2009/10 had a off-mode power consumption close to zero, information off-mode power consumption was not available in 2011. The standby power consumption was 0.17 W and 0.2 W in 2009/10 and 2011, respectively. As it appears from Table B.1 in Appendix B Sony Bravia does comply with all of the ecolabels.

*Chemicals*

With regards to the chemicals in the product it is assumed that Sony Bravia complies with the RoHS Directive, as non-compliant products cannot be put on the market in the EU, and hence complies with most of the requirements. It has, however, not been possible to find information on many of the TCO'06 requirements, see Table B.2 in Appendix B.

*General Eco-design Requirements*

It has been difficult to obtain information on Sony Bravia's compliance with the general eco-design requirements. As Sony Bravia 2009/2010 has been awarded the Nordic ecolabel and the European Ecolabel compliance is assumed even if no information was available. Table B.3 in Appendix B summarises compliance of Sony Bravia with the ecolabels and the requirements of the IM.

*Environmental Information*

Data on environmental information to the consumer has been obtained though studying the user manuals and studying the web pages of Sony. In Table B.4 in Appendix B Sony Bravia's compliance with ecolabels and the IM is presented.

### 5.2.4 Philips

In the 2011 analysis, it was found important to include Philips TVs in the study as Philips has achieved significant results in terms of low power consumption for TVs, see Figure 5-3. The TVs investigated are Philips Econova 42" and Philips 46" of the 7000 series, which have been awarded the European Ecolabel. Both TVs are based on the LED technology and several features ensure low power consumption. These features are 0 Watt Power-off-switch, light sensor, eco mode and picture mute (for radio), auto switch-off timer and the Econova further has an Eco settings menu. (Philips, 2010; Philips, 2011)

In the following sections Philips' TVs will be compared to the ecolabel requirements and the IM. The complete overview of the comparison is presented in section 5.2.5, whereas more overall comments to the comparison are given in the below sections.

*Power Consumption in on-mode*
As illustrated in Figure 5-3 both TVs perform very well on power consumption in on-mode. Philips Econova can comply with all of the requirements, while the 46" from the 7000 series can comply with all requirements except the Energy Star 2012 requirement.

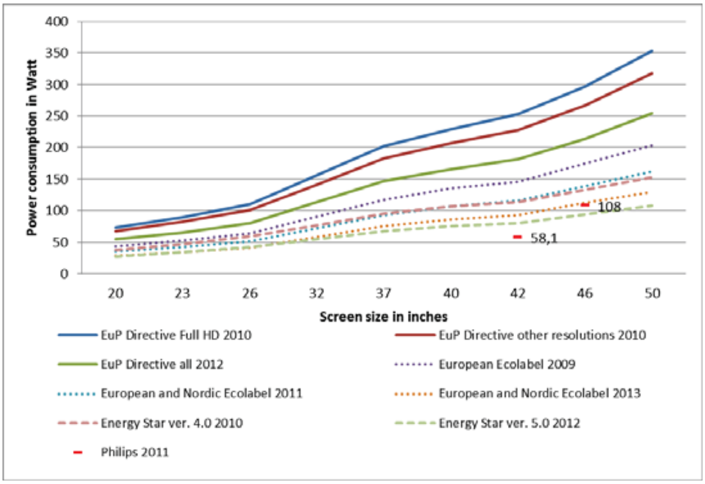



Figure 5-3 Philips Econova and 7000 series power consumption in on-mode compared to ecolabels and the requirements of the IM (Philips, 2010; Philips 2011)

*Power Consumption in Off-mode and Standby*
Philips Econova and 7000 series perform very well when it comes to standby and off-mode power consumption. The off-mode power consumption is 0.01 W and the standby power consumption is 0.15 W and 0.07 W, respectively for the two analysed TVs. As it appears from Table B.1 in Appendix B, Philips complies with all of the ecolabels.

*Chemicals*
With regard to the chemicals in the product it is assumed that Philips complies with the RoHS Directive, as non-compliant products cannot be put on the market in the EU and hence complies with most of the requirements. It

has, however, not been possible to find information on many of the TCO'06 requirements, see Table B.2 in Appendix B.

*General Eco-design Requirements*
It has been difficult to obtain information on Philips' compliance with the general eco-design requirements. As the investigated Philips TVs are awarded the European Ecolabel compliance is assumed even if no information was available. Table B.3 in Appendix B summarises compliance of Philips with the ecolabels and the requirements of the IM.

*Environmental Information*
Data on environmental information to the consumer has been obtained though studying the user manuals and studying the web pages of Philips. In Table B.4 in Appendix B Philips TVs' compliance with ecolabels and the IM is presented.

#### 5.2.5 Comparison of BAT, Implementing Measures and Ecolabels

In the above sections, the performance of best available technologies (BAT) in this case Samsung's LED TVs and Sony Bravia and Philips Econova and 7000 series has been compared to the IM and Ecolabels. Appendix B summarises the comparison in tables.

Not surprisingly, the TVs including BAT's can easily comply with the requiremenst of the IM and several of the ecolabels, both when it comes to on-mode and standby power consumption. Looking at the development that has happened between the 2009/2010 and 2011 analysis it is clear that it is possible to visibly lower the power consumption within a year. For instance, Samsung 6 series has achieved a 40W reduction on the 40" TV.

Especially for the on-mode power consumption requirement, it becomes clear that the IM has not taken the performance level of new technologies into account, as all analysed TVs have significantly lower power consumption than what is required. Further, it should be noted that in the Sony case the best performing TVs in terms of power consumption where in 2011 not the ecolabelled TVs. Many of the TVs, especially in 2011 also perform better than what the European and Nordic Ecolabel require. This could be an indicator that the process of setting requirements in the ecolabels cannot follow the fast technological development and that the process of obtaining the label is too slow or complicated.

With regard to the performance on other environmental areas, the TVs including BATs also perform well as they have obtained different ecolabels. However, it has not been possible to find information on all areas.

### 5.3 Currently available TVs without ecolabels

This section focuses on current available TVs without an ecolabel and hence the group of TV expected to have most difficulties complying with the requirements of the EuP Directive. TVs from Samsung, Sony, Panasonic, LG, Grundig and Bang & Olufsen have been investigated.

The TVs are randomly selected covering different screen sizes and technologies. It is chosen only to investigate on-mode power consumption, standby and off-mode power consumption as these are the focus areas of the requirements of the EuP Directive and this information is easily available at the producers' web pages. In the following sections the three areas will be elaborated.

### 5.3.1 Power Consumption in On-mode

In Figure 5-4 the on-mode power consumption of several TVs without ecolabels is compared to the requirements of the EuP Directive and ecolabels.

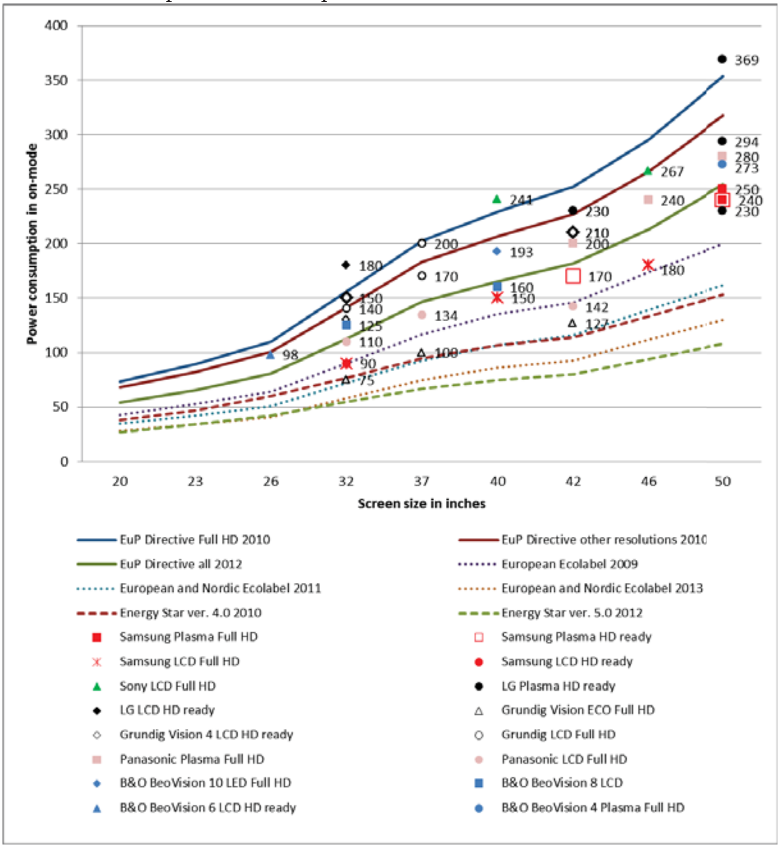



FIGURE 5-4 ON-MODE POWER CONSUMPTION OF CURRENTLY AVAILABLE TVS NOT AWARDED AN ECOLABEL COMPARED TO THE REQUIREMENTS OF THE EUP DIRECTIVE AND ECOLABELS.[9] (LG ELECTRONICS, 2010), (GRUNDIG, 2010A), (GRUNDIG, 2010B), (PANASONIC EUROPE LTD, 2010), (SONY, 2010), (SAMSUNG, 2010) AND (BANG & OLUFSEN, 2010)

From Figure 5-4 it appears that all investigated TVs from Samsung, Grundig, Panasonic and Bang & Olufsen can comply with the requirements of the EuP Directive of 2010. For Samsung, the Ecovision from Grundig, the LCD TVs from Panasonic and Bang & Olufsen's 40" BeoVision 8 can even comply with the requirement coming into force in 2012.

For the TVs from Sony the picture is slightly different; the 40" TV cannot comply with any of the EuP requirements, whereas the 46" TV can comply with the 2010 requirements. Also for the LG TVs the requirements are a challenge; for the three investigated plasma TVs only one (the 50" 230 W) can comply with the 2012 requirement, and two can comply with the 2010

[9] The on-mode power consumption values for Panasonic are the average on-mode power consumption, based on IEC 62087 Ed.2 measurement method.

requirement (the 50" 230 W and 294 W). For the LG LCD TVs the two investigated 32" (180 W and 150 W) cannot comply with any of the requirements. Regarding the 42" TVs, one can comply (210 W) and one cannot comply (230 W) with the 2010 requirement.

It is interesting to notice that already 50 % of all investigated TVs already comply with the IM for 2012. Of course the IM will lead to a fade out of the products that do not comply with the requirements, but it seems questionable how much further the IM will trigger ecoinnovation, than what the producers already are doing on their own.

### 5.3.2 Power Consumption in Off-mode and Standby

The investigated standby and off-mode power consumption of the selected TVs by Samsung, Panasonic and the Eco TV from Grundig can comply with the tier 1 and tier 2 passive standby requirements of the EuP Directive. See table C.1 in Appendix C.

Samsungs TVs can even comply with the standby requirements of all the ecolabels. Sony TVs cannot comply with the EuP requirements as the media receiver consumes too much power. The investigated TVs from Grundig, LG and Bang & Olufsen can comply with the 2010 requirement of the IM, but not the 2012 requirement. Unfortunately, it has not been possible to find information on other requirements than standby.

### 5.3.3 Comparison of available TVs, Implementing Measures and Ecolabels

In Section 5.3.1 and 5.3.2 the performance TVs without an ecolabel have been compared to the requirements of the IM and ecolabels, as these TVs were expected to have the most difficulties on complying with the requirements. Interestingly, our analysis showed that many TVs already comply with the IM requirements of 2012, both for standby and on-mode power consumption. Of course, the TVs must comply with the standby requirement as it stepped into force January 2010. It can also be assumed that the producers have taken measures to comply with the on-mode power consumption requirement, which steppes into force in August 2010. It is though puzzling that so many TVs already comply with requirements for 2012, both for standby and on-mode.

## 5.4 Subconclusion

From the above analysis two main conclusions can be drawn. Firstly, since all BAT TVs can easily comply with the IM and around half of the currently available technology TVs can comply with the IM, it seems that IM have not been able to adapt to the fast technological development. It appears clearly that for instance the LED technology has not been considered mature enough in the preparatory study phase to have an influence on the requirement development.

Secondly, in the case of BAT it seems that especially the European and Nordic Ecolabel have not either been able to keep up to date with the technological development. Many of the BAT TVs particularly in the 2011 analysis had on-mode power consumptions that were visibly lower than the requirements. This is problematic as precisely the ecolabels are supposed to represent the best on the market in terms of environmental performance.

Hence, the question seems obvious; do the requirements of the IM really trigger substantial eco innovation? The question is relevant regardless whether the producers have already implemented measures to comply with the requirements or not. In both cases, the requirements set up by the IM could have been more ambitious, if the goal is to improve eco-innovations on TVs substantially.

However, it is important to be aware of that small producers of TVs may have a more difficult access to new technology than the big producers. If the requirements are tightened that only the best performing technologies can comply it might distort the competition between the small and big producers, in an undesired way, which is not the purpose if the IM and the EuP Directive.

# 6 Energy Labelling for TVs

In this chapter the Energy Labelling Directive and its IM for TVs are analysed and compared to the requirements of the IM of the EuP Directive and the different ecolabels. The Energy Labelling for TVs was adopted in 2010 and serves as a supplement to the IM of the EuP Directive. This means that where the IM of the EuP Directive are minimum requirements, expelling the worst performing products from the market, the Energy Labelling are meant as incentives for the companies to achieve higher energy efficiency of their products. This difference in scope is illustrated in Figure 1-2 in Section 1.1.1.

In 1992 the first energy-labelling Directive was adopted. The Directive set a framework for mandatory energy labelling requirements for household appliances, such as refrigerators and washing machines. In 2008, a revision of the Directive began with the aim of including energy related products in the scope.

As in the EuP Directive the requirements of the Energy Labelling Directive are set up in Implementing Measures. TVs are also included in the scope in the revised Directive and in September 2010 the regulation with the requirements was adopted (European Commission, 2010).

The labelling requirements are that televisions placed on the European market must be supplied with a label containing the following information (European Commission, 2010):

1. the suppliers name or trade mark
2. the energy efficiency class
3. the on-mode power consumption and the annual on-mode energy consumption
4. the screen diagonal

The energy efficiency class is based on an energy efficiency index (EEI), which is calculated as follows (European Commission, 2010):

$EEI = P/P_{ref}(A)$, where

$P_{ref}(A) = P_{basic} + A \cdot 4.3224$ Watts/dm$^2$
$P_{basic}$ = 20 Watts for television sets with one tuner/receiver and no hard disc
$P_{basic}$ = 24 Watts for television sets with hard disc(s)
$P_{basic}$ = 24 Watts for television sets with two or more tuners/receivers
$P_{basic}$ = 28 Watts for television sets with hard disc(s) and two or more tuners/receivers
$P_{basic}$ = 15 Watts for television monitors
A is the visible screen area in dm$^2$
P is the on-mode power consumption of the television in Watts

The energy efficiency class and index is illustrated in Table 6.1.

Table 6.1 The proposed energy efficiency class of TVs (European Commission, 2010: Annex 1)

| Energy Efficiency Class | Energy Efficiency Index |
|---|---|
| A+++ (most efficient) | EEI < 0.10 |
| A++ | 0.10 > EEI < 0.16 |
| A+ | 0.16 > EEI < 0.23 |
| A | 0.23 > EEI < 0.30 |
| B | 0.30 > EEI < 0.42 |
| C | 0.42 > EEI < 0.60 |
| D | 0.60 > EEI < 0.80 |
| E | 0.80 > EEI < 0.90 |
| F | 0.90 > EEI < 1.00 |
| G (least efficient) | 1.00 > EEI |

The label is be gradually tightened, meaning that on the label applicable 12 months after the publication of the Implementing measure the most energy efficient label possible to obtain is A. From 2014, it will be possible to obtain the label A+ and the F will be the least efficient label. In 2017, A++ will be the most efficient label and E will be the least efficient label. Finally in 2020 the most efficient label is A+++ and E will be the least efficient label. (European Commission, 2010)

## 6.1 Comparison of the Energy Efficiency label with the EuP Directive and ecolables

Compared to the EuP Directive and the ecolabels presented in this report the Energy labelling Directive has a new approach as the label is assigned on the basis of an energy efficiency index. It does not forbid the entry into the market if certain energy consumption values are not met, but the manufacturers are forced to label their products correctly. In this way the Energy labelling Directive can be seen as similar to ecolabels – only with the difference that the label is mandatory.

In Figure 6-1 the requirements of the Energy Labelling Directive for TV sets are compared to the requirements of the EuP Directive and the ecolabels. As the Energy Labelling Directive works with an energy efficiency index that is divided in intervals, the lines in Figure 6-1 represent the maximum power consumption the products must have in order to obtain the given label. As an example, in order for the product to obtain the energy efficiency label A+ the product must have a power consumption that is between the A+ line and the A++ line. In order to obtain the label G the power consumption of the product must be above the line of F.

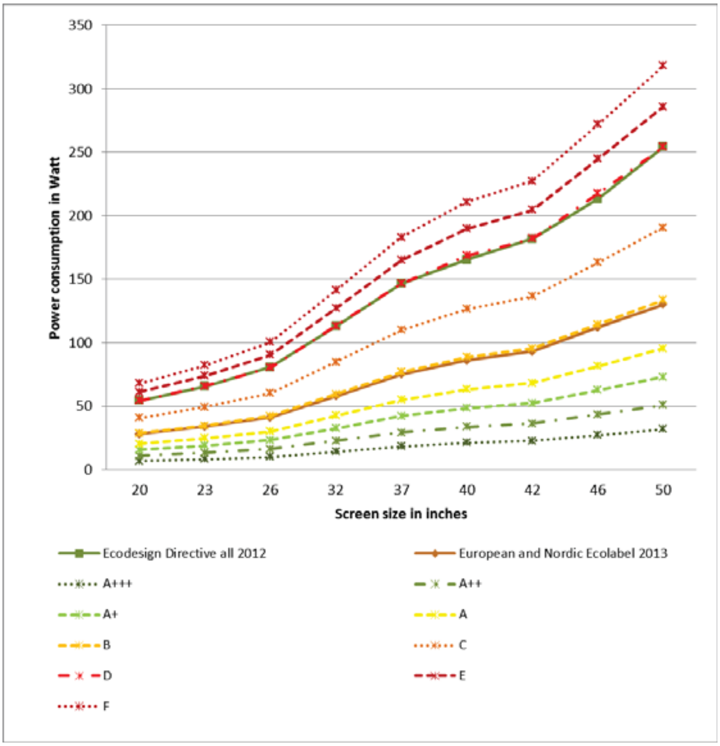



Figure 6-1 Comparison of the on-mode power consumption Requirements of the Energy Labelling Directive with the EuP Directive and ecolabels. Based on (Eurpean Commission, 2009c: Annex 1), (European Commission, 2009b), (Energy Star, 2009) and (European Commission, 2010).

Figure 6-1 illustrates that the energy efficiency label covers all TVs from the most inefficient that cannot comply with the requirements of the EuP Directive to TVs that are much more efficient than the ecolabels. The role of the EuP Directive as minimum directive removing the worst performing products from the market also becomes clear. The 2010 Full HD requirement would comply with a G label, which is the least energy efficient; the 2010 requirement for other resolution is approximately on the same line as the maximum of the F label. Even the 2012 EuP requirement would only comply with a D label.

When comparing the Energy efficiency label to the requirements of the ecolabels, it is interesting to see that even the strictest European Ecolabel requirement applicable from 2013 is on the level of the B label of the energy efficiency label and the A label is stricter. Both the European and the Nordic Ecolabel are continuously updated and tightened, but it seems that despite this mechanism the energy efficiency label has a stricter point of departure, thereby setting higher demands on the products. A simple solution is that the eco-label always should be equivalent to minimum A-label or better.

It can be argued that where the role of EuP Directive as driver for eco-innovations of TVs is rather unclear, then the energy-labelling scheme will take over and create incentives for producers to improve their products' energy efficiency. However, once again the focus of the label is solely on energy efficiency in on-mode and other significant environmental impacts are not addressed in the label. Therefore, while the energy efficiency label might create the right incentives for producer to improve their TVs' energy efficiency other measures are necessary in order to improve the environmental performance of TVs in a life cycle perspective.

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# Comparison of Implementing Measures and Ecolabels

Table A.1 Comparison of standby and off-mode requirements of Implementing Measures and ecolabels

| | Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 |
|---|---|---|---|---|---|
| Off-mode tier 1 | Compliance in 2010: ≤ 1,00 W | | | | |
| Off mode tier 2 | Compliance in 2011:<br>≤ 0,5 W if the TV has an easily visible off switch putting the TV in off-mode using ≤ 0,01 W<br>Otherwise: ≤ 0,3 W | | | | |
| Off mode | TVs shall have an off-mode and/or standby-mode, and/or another condition which does not exceed the applicable power consumption requirements for off-mode and/or standby-mode when the TV is connected to the mains power source. | | All products shall have a clearly visible on-off switch | | |
| Passive standby tier 1 | Compliance in 2010: ≤ 1,00 W<br>≤ 2,00 W if the TV is providing information or status display | ≤ 0,50 W if energy consumption in off mode < 0,01 W<br>All other equipment: ≤0,3 W | ≤ 0,50 W if energy consumption in off mode < 0,01 W<br>All other equipment: ≤0,3 W | sleep mode: ≤ 1 W | ≤ 1W |

| | Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 |
|---|---|---|---|---|---|
| Passive standby tier 2 | Compliance in 2011: ≤ 0,50 W<br>≤ 1,00 W if the TV is providing information or status display | | | | |
| Passive standby | For TV sets which consist of a display, and one or more tuner(s)/receiver(s) and optional additional functions for data storage and/or display such as digital versatile disc (DVD), hard disk drive (HDD) or videocassette recorder (VCR) in one or more separate units, points (a) to (c) apply for the display and the separate unit(s) individually | | | | |
| Active standby low tier 1 | | | | Additional: 01.05.2010 ≤ 0.08 kWh/day | |
| Active standby low tier 2 | | | | Additional: 01.05.2012 ≤ 0.02 kWh/day | |

| | Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 |
|---|---|---|---|---|---|
| Automatic power down | Compliance in 2011:<br>After no more than 4 hours in on mode following the last user interaction and/or a channel change, the TVs shall be automatically switched from on mode to:<br>— standby-mode, or,<br>— off-mode, or,<br>— another condition which does not exceed the applicable power consumption requirements for off-mode and/or standby-mode | | | | |
| | TVs shall display an alert message before the automatic switch from on mode to the applicable condition/modes.<br>This function shall be set as default. | | | | |
| Home-Mode | TVs with forced menu on initial activation of the television shall provide a 'home-mode' in the forced menu, which shall be the default choice on initial activation of the TV. If the user selects a mode other than 'home mode' on initial activation of the TV, a second selection process shall be prompted to confirm this choice. | | | | |

Table A..2 Comparison of chemical requirements of the Implementing Measures and ecolabels

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 |
|---|---|---|---|---|
| Substances regulated in the RoHS Directive 2002/95/EC | The product must comply with the RoHS Directive 2002/95/EC | Products must not contain cadmium, lead, mercury, chromium 6+, DecaBDE (deca brominated diphenyl ether), PBB (polybrominated biphenyls) and PBDE (polybrominated diphenyl ethers). Unless their maximum concentration value of is equal to or lower than the threshold laid down in Directive 2002/95/EC and subsequent amendments. In the case of PBB and PBDE the maximum concentration value is <0.1%. | | Components must comply with the RoHS Directive 2002/95/EC and its amendments<br>Exempted are mercury in background lighting systems and PBB and PBDE in printed wiring boards |
| | Mercury content in fluorescent lamps: The total, amount of mercury in all lamps, per screen, shall be no greater than 75 mg Hg for screen sizes up to 40”, and no greater than 99 mg Hg for screen sizes above 40“ | The background lightning in the TV-screen can not have any mercury (Hg) content. | | decaBDE is not allowed even if EU has decided to except it from the RoHS Directive 2002/95/EC |
| | | Chlorinated paraffin may not be used in products. | | |

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 |
|---|---|---|---|---|
| Other flame retardants | | Flame retardants containing organohalogen compounds are not permitted | | Plastic parts weighing more than 25 g. shall not contain flame retardants that contain bromine or chlorine. Printed Wiring Boards are exempted. |
| | Plastic parts may not contain flame retardants, or preparations that are assigned or may be assigned the risk phrases: R40 (possible risk of cancer), R45(may cause cancer), R46 (may cause heritable generic damage), R50 (very toxic to aquatic organisms), R51 (toxic to aquatic organisms), R52 (harmful to aquatic organisms), R53 (may cause long term adverse effects in the aquatic environment), R60(may impair fertility) and R61 (may cause harm to unborn child), R62 (possible risk of impaired fertility), R63 (possible risk of harm to the unborn child) | Plastic parts may not contain flame retardants which are assigned or may be assigned the risk phrases: R45(may cause cancer), R46 (may cause heritable generic damage), R60(may impair fertility) and R61 (may cause harm to unborn child) | | The material specifications shall be provided for plastic parts and PWB laminates that weigh more than 25 grams and which have flame retardant concentrations above 0.5 percent by weight. |
| Batteries | | | | Limit values per listed part:<br>Mercury = 2ppm<br>Cadmium = 5 ppm<br>Lead = 50 ppm |

Table A.3 Comparison of general ecodesign requirements of the Implementing Measures and ecolabels

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 |
|---|---|---|---|---|
| Dismantling | The manufacturer shall demonstrate that the product can be easily dismantled by professional recyclers | The manufacturer shall demonstrate that the product can be easily dismantled by professional recyclers | | Connections to be separated during disassembly of FDP must be easy to take apart in order to not damage the mercury lamps. This means that gluing and welding must not be used to bond parts. |
| | | | | Plastic parts weighing more than 25 g must be material-coded in accordance with ISO 11469 and ISO 1043-1, -2, -3, and -4. Exempted are laminates for printed Wiring board |
| | | | | The total amount of mercury must be declared in a table |
| | | | | No more than two different types of plastic materials are accepted for parts weighing more than 100 g in each unit.<br>The light guide in FPD panels are exempted |
| | | | | There shall be no internal or external metallization of the FPD outer plastic casing and foot |
| | | | | Moulded-in or glued metal parts are not accepted |

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 |
|---|---|---|---|---|
| Life-time extension | The manufacturer shall offer a commercial guarantee to ensure that the product will function for the least two years | The manufacturer shall offer a commercial guarantee to ensure that the product will function for the least two years | | |
| | The availability of compatible electronic replacement parts shall be guaranteed for seven years from the time the production ceases | The availability of compatible electronic replacement parts shall be guaranteed for seven years from the time the production ceases | | |

Table A.4 Comparison of information requirements of the Implementing measures and ecolabels

| Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 |
|---|---|---|---|---|
| | Information that the product has been awarded the flower | Information that the product has been awarded the Nordic Ecolabel | Information about the Energy Star | |

| Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 |
|---|---|---|---|---|
| The product's power consumption in on-mode, standby and off-mode | The product's power consumption information in various modes; on, off and passive standby, including information on energy savings possible in different modes | The product's power consumption information in various modes; on, off and passive standby | | |
| | Explanations of how to reduce power consumption when the product is not being used | Explanations of how to reduce power consumption when the product is not being used | Information about the benefits of keeping the TV in its default mode | |
| If the product contains mercury or lead | | | | |
| | The television's average annual energy consumption expressed in kWh, calculated on the basis of the on-mode power consumption, operating 4 hours a day and 365 days a year | Average annual energy consumption | | |
| | Information that the energy efficiency cuts energy consumption and thus saves money by reducing the electricity bill | | | |
| | The position of the hard off switch | | | |

| Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 |
|---|---|---|---|---|
| | Repair information regarding who is qualified to repair products | Repair information regarding who is qualified to repair products | | |
| | | | | A product declaration shall be provided for the FPD |
| | End-of-life instructions for proper disposal | End-of-life instructions for proper disposal | | Information in the user's manual of the possibility to dispose of the FPD by environmentally acceptable recycling. |
| The ratio of the peak luminance of the on-mode or home-mode condition of the TV as delivered by the manufacturer and the peak luminance of the brightest on-mode condition provided by the TV, expressed in percentage, rounded to the nearest integer | | | | |

References: (Energy Star, 2009), (European Commission, 2009a), (European Commission, 2009b), (Nordic Ecolabelling. 2009) and (Rudling, Jan and Helena Nordin, 2006)

# Comparison of Best Available Technologies Implementing Measures and Ecolabels

Table B.1 Comparison of Samsung LED TVs, Sony Bravia, Philips, Implementing Measures and Ecolabels on standby and of-mode power consumption.

| | Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series 2009/2010 | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|---|
| **Off-mode tier 1** | Compliance in 2010: ≤ 1,00 W | | | | | No informatio n available | No informatio n available | ~ 0 Watt | No informatio n available | <0.01 W (Econova) |
| **Off mode tier 2** | Compliance in 2011:<br>≤ 0,5 W if the TV has an easily visible off switch putting the TV in off-mode using ≤ 0,01 W<br>Otherwise: ≤ 0,3 W | | | | | No informatio n available | No informatio n available | ~ 0 Watt | No informatio n available | <0.01 W(Econov a) |

| | Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series 2009/2010 | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|---|
| **Off mode** | TVs shall have an off-mode and/or standby-mode, and/or another condition which does not exceed the applicable power consumption requirements for off-mode and/or standby-mode when the TV is connected to the mains power source. | | All products shall have a clearly visible on-off switch | | | Off switch on the front of the television | No informatio n available | Energy Saving Switch on the side of the television | No informatio n available | 0 Watt Power-off-switch |
| **Passive standby tier 1** | Compliance in 2010: ≤ 1,00 W<br>≤ 2,00 W if the TV is providing information or status display | ≤ 0,50 W if energy consumpti on in off mode < 0,01 W<br>All other equipment: ≤0,3 W | ≤ 0,50 W if energy consumpti on in off mode < 0,01 W<br>All other equipment: ≤0,3 W | sleep mode: ≤ 1 W | ≤ 1W | <0.1 W | <0.3 W - 0.06 W | 0,17 W | 0.2 W | 0.15 W (7000)<br>0.07 W (Econova) |
| **Passive standby tier 2** | Compliance in 2011: ≤ 0,50 W<br>≤ 1,00 W if the TV is providing information or status display | | | | | <0.1 W | <0.3 W - 0.06 W | 0,17 W | 0.2 W | 0.15 W (7000)<br>0.07 W (Econova) |

| | Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series 2009/2010 | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|---|
| **Passive standby** | For TV sets which consist of a display, and one or more tuner(s)/receiver(s) and optional additional functions for data storage and/or display such as digital versatile disc (DVD), hard disk drive (HDD) or videocassette recorder (VCR) in one or more separate units, points (a) to (c) apply for the display and the separate unit(s) individually | | | | | | | | | |
| **Active standby low tier 1** | | | | Additional: 01.05.2010 ≤ 0.08 kWh/day | | No information available | No information available | No information available | No information available | No information available |
| **Active standby low tier 2** | | | | Additional: 01.05.2012 ≤ 0.02 kWh/day | | No information available | No information available | No information available | No information available | No information available |

| | Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series 2009/2010 | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|---|
| **Automatic power down** | Compliance in 2011:<br>After no more than 4 hours in on mode following the last user interaction and/or a channel change, the<br>TVs shall be automatically switched from on mode to:<br>— standby-mode, or,<br>— off-mode, or,<br>— another condition which does not exceed the applicable power consumption requirements for off-mode and/or standby-mode | | | | | No informatio n available | No informatio n available | No informatio available | No informatio available | Auto switch-off timer |
| | TVs shall display an alert message before the automatic switch from on mode to the applicable condition/modes. This function shall be set as default. | | | | | No informatio n available | No informatio n available | No informatio n available | No informatio n available | No informatio n available |

| | Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series 2009/2010 | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|---|
| **Home-Mode** | TVs with forced menu on initial activation of the television shall provide a 'home-mode' in the forced menu, which shall be the default choice on initial activation of the TV. If the user selects a mode other than 'homemode' on initial activation of the TV, a second selection process shall be prompted to confirm this choice. | | | | | No information available | No information available | No information available | No information available | No information available |

Table B.2 Comparison of Samsung LED TVs, Sony Bravia, Philips and Ecolabels on chemicals in the product

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| **Substances regulated in the RoHS Directive 2002/95/EC** | The product must comply with the RoHS Directive 2002/95/EC | PBB, PBDE, or chlorinated paraffins may not be used in the products unless the concentration value is ≤ the | | Components must comply with the RoHS Directive 2002/95/EC and its amendments Excempted are | Complies with the RoHS Directive 2002/95/EC and its amendments | Complies with the RoHS Directive 2002/95/EC and its amendments | Complies with the RoHS Directive 2002/95/EC and its amendments | Complies with the RoHS Directive 2002/95/EC and its amendments | Complies with the RoHS Directive 2002/95/EC and its amendments |

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | | threshold specified in Directive 2002/95/EC | | mercury in background lighting systems and PBB and PBDE in printed wiring boards | | | | | |
| | Mercury content in fluorescent lamps: The total, amount of mercury in all lamps, per screen, shall be no greater than 75 mg Hg for screen sizes up to 40", and no greater than 99 mg Hg for screen sizes above 40" | Mercury content in LCD displays: In total, the lamp shall contain no more than 75 mg Hg for screen sizes up to 40", and no more than 99 mg Hg for screen sizes above 40" | | decaBDE is not allowed even if EU has decided to excempt it from the RoHS Directive 2002/95/EC | There are no fluorescent lamps as the LED technology is being used, hence no mercury is used | There are no fluorescent lamps as the LED technology is being used, hence no mercury is used | Sony Bravia complies with the European Ecolabel | There are no fluorescent lamps as the LED technology is being used, hence no mercury is used | Philips complies with the European Ecolabel |

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | | Flame retardants containing cadmium, lead, mercury, chromium 6+, PBB, PBDE shall not used in the products unless the concentration value is ≤ the threshold specified in Directive 2002/95/EC | | | Samsung complies with the Nordic Ecolabel regarding flame retardants | Samsung complies with the Euroepan Ecolabel regarding flame retardants in plastics | Complies with the RoHS Directive 2002/95/EC and its amendments | No information available | Philips complies with the Euroepan Ecolabel regarding flame retardants in plastics |
| **Other flame retardants** | | Flame retardants containing organohalogen compounds are not permitted | | Plastic parts weighing more than 25 g. shall not contain flame retardants that contain bromine or chlorine. Printed Wiring Boards are | Samsung complies with the Nordic Ecolabel regarding flame retardants<br><br>No information available on | Samsung complies with the Euroepan Ecolabel regarding flame retardants in plastics | There are no halogens in the packaging or the parts of Sony Bravia<br><br>No information available on TCO'06 compliance | There are no halogens in the packaging or the parts of Sony Bravia<br><br>No information available on TCO'06 compliance | No information available |

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | | | | excempted. | TCO'06 compliance | | | | |
| | Plastic parts may not contain flame retardants, or preparations that are assigned or may be assigned the risk phrases: R40 (possible risk of cancer), R45(may cause cancer), R46 (may cause heritable generic damage), R50 (very toxic to aquatic organisms), R51 (toxic to aquatic organisms), | Plastic parts may not contain flame retardants which are assigned or may be assigned the risk phrases: R45(may cause cancer), R46 (may cause heritable generic damage), R60(may impair fertility) and R61 (may cause harm to unborn child) | | The material specifications shall be provided for plastic parts and PWB laminates that weigh more than 25 grams and which have flame retardant concentrations above 0.5 percent by weight. | Samsung complies with the Nordic Ecolabel regarding flame retardants in plastic parts<br><br>May contain plastic parts, which are assigned the risk phrase R40 (possible risk of cancer), R62 (possible risk of impaired fertility) and R63 (possible risk of harm to unborn child) | Samsung complies with the Euroepan Ecolabel regarding flame retardants in plastics | Sony Bravia complies with the European Ecolabel<br><br>No information available on TCO´06 compliance | No information available | Philips complies with the European Ecolabel<br><br>No information available on TCO´06 compliance |

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | R52 (harmful to aquatic organisms), R53 (may cause long term adverse effects in the aquatic environment), R60(may impair fertility) and R61 (may cause harm to unborn child), R62 (possible risk of impaired fertility), R63 (possible risk of harm to the unborn child) | | | | No information available on TCO'06 compliance | | | | |
| **Batteries** | | | | Limit values per listed part: Mercury = 2ppm Cadmium = 5 ppm | No information available | No information available | No information available | No information available | No information available |

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Lead = 50 ppm | | | | | |

Table B.3 Comparison of Samsung LED TVs, Sony Bravia, Philips and Ecolabels on general eco-design requirements

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| **Dismantling** | The manufacturer shall demonstrate that the product can be easily dismantled by professional recyclers | The manufacturer shall demonstrate that the product can be easily dismantled by professional recyclers | | Connections to be seperated during dissassembly of FDP must be easy to take apart in order to not damage the mercury lamps. This means that gluing and welding must not be used to bond parts. | Samsung complies with the Nordic Ecolabel regarding dismantling | Samsung complies with the European Ecolabel regarding dismantling | Sony Bravia complies with the European and the Nordic Ecolabel | No information available | Philips complies with the European Ecolabel |

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Plastic parts weighing more than 25 g must be material-coded in accordance with ISO 11469 and ISO 1043-1, -2, -3, and -4. Excempted are laminates for printed Wiring board | No information available | No information available | All parts complies with ISO 11469 | No information available | No information available |
| | | | | The total amount of mercury must be declared in a table | There are no flourescent lamps as the LED technology is being used, hence no mercury is used | There are no flourescent lamps as the LED technology is being used, hence no mercury is used | No information in the user manuals | There are no flourescent lamps as the LED technology is being used, hence no mercury is used | There are no flourescent lamps as the LED technology is being used, hence no mercury is used |

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | | | | No more than two different types of plastic materials are accepted for parts weighing more than 100 g in each unit. The light guide in FPD panels are excempted | No information available | No information available | No information available | No information available | No information available |
| | | | | There shall be no internal or external metallization of the FPD outer plastic casing and foot | No information available | No information available | No information available | No information available | No information available |
| | | | | Moulded-in or glued metal parts are not accepted | No information available | No information available | No information available | No information available | No information available |

| | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| **Life-time extension** | The manufacturer shall offer a commercial guarantee to ensure that the product will function for the least two years | The manufacturer shall offer a commercial guarantee to ensure that the product will function for the least two years | | | Samsung complies with the European and the Nordic Ecolabel regarding commercial guarantee | Samsung complies with the European Ecolabel regarding commercial guarantee | Sony Bravia complies with the EU Flower and the Nordic Ecolabel | No information available | Philips complies with the European Ecolabel regarding commercial guarantee |
| | The availability of compatible electronic replacement parts shall be guaranteed for seven years from the time the production ceases | The availability of compatible electronic replacement parts shall be guaranteed for seven years from the time the production ceases | | | Samsung complies with the European and the Nordic Ecolabel regarding replacement parts | Samsung complies with the European Ecolabel regarding commercial guarantee | Sony Bravia complies with the EU Flower and the Nordic Ecolabel | No information available | Philips complies with the European Ecolabel regarding replacement parts |

Table B.4 Comparison of Samsung LED TVs, Sony Bravia, Philips, Implementing Measures on information requirements

| Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | Information that the product has been awarded the flower | Information that the product has been awarded the Nordic Ecolabel | Information about the Energy Star | | Samsung complies with the European and the Nordic Ecolabel regarding information on awarded ecolabels | Samsung complies with the European and the Nordic Ecolabel regarding information on awarded ecolabels | Sony Bravia complies with the European Ecolabel | Not in compliance, sinse it is not ecolabelled | Philips complies with the European Ecolabel regarding information on awarded ecolabels |
| The product's power consumption in on-mode, standby and off-mode | The product's power consumption information in various modes; on, off and passive standby, including information on energy savings possible in different modes | The product's power consumption information in various modes; on, off and passive standby | | | Samsung complies with the European and the Nordic Ecolabel regarding information on the product's power consumption | Samsung complies with the European and the Nordic Ecolabel regarding information on the product's power consumption | Sony Bravia complies with the European Ecolabel | Information on power consumption in standby and on-mode is provided | Philips complies with the European Ecolabel regarding information on the product's power consumption |

| Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | Explanations of how to reduce power consumption when the product is not being used | Explanations of how to reduce power consumption when the product is not being used | Information about the benefits of keeping the TV in its default mode | | It is in the user manuals recommended to unplug the set from the mains and aerial when being away for longer periods of time, for instance on holiday | It is in the user manuals recommended to | The different energi savings functions are described in the user manual | No information available | It is in the user manuals explained how to access the energy saving functions |
| If the product contains mercury or lead | | | | | No mercury is being used in the LED technology | No mercury is being used in the LED technology | No information available | No information available | No mercury is being used in the LED technology |
| | The television's average annual energy consumption expressed in kWh, calculated on the basis of the on-mode power | Average annual energy consumption | | | Samsung complies with the European and the Nordic Ecolabel regarding information on the product's average | Samsung complies with the European and the Nordic Ecolabel regarding information on the product's average | Sony Bravia complies with the European Ecolabel | No information available | Philips complies with the European Ecolabel regarding information on the product's average annual energy consumption |

| Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | consumption, operating 4 hours a day and 365 days a year | | | | annual energy consumption | annual energy consumption | | | |
| | Information that the energy efficiency cuts energy consumption and thus saves money by reducing the electricity bill | | | | No information in the user manuals | No information in the user manuals | No information on the user manual | No information available | Philips complies with the European Ecolabel |
| | The position of the hard off switch | | | | The position of the hard off switch is illustrated in the user manuals | The position of the hard off switch is illustrated in the user manuals | The position of the hard off switch is illustrated in the user manuals | No information available | The position of the hard off switch is illustrated in the user manuals |
| | Repair information regarding who is qualified to repair | Repair information regarding who is qualified to repair | | | No information in the user manuals | No information in the user manuals | It is in the user manual written that you should contact your | No information available | Philips complies with the European Ecolabel |

| Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| | products | products | | | | | Sony Service Center or dealer when the televisions is broken | | |
| | | | | A product declaration shall be provided for the FPD | No information in the user manuals | No information in the user manuals | No information in the user manuals | No information available | No information available |
| | End-of-life instructions for proper disposal | End-of-life instructions for proper disposal | | Information in the user's manual of the possibility to dispose of the FPD by environmental ly acceptable recycling. | No information in the user manuals | No information in the user manuals | No information in the user manuals | No information available | Philips complies with the European Ecolabel |

| Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star ver. 4.0 and 5.0 | TCO'06 | Samsung 6, 7, 8 series | Samsung 6, 8 series 2011 | Sony Bravia 2009/2010 | Sony Bravia 2011 | Philips |
|---|---|---|---|---|---|---|---|---|---|
| The ratio of the peak luminance of the on-mode or home-mode condition of the TV as delivered by the manufacturer and the peak luminance of the brightest on-mode condition provided by the TV, expressed in percentage, rounded to the nearest integer | | | | | No information available | No information in the user manuals | No information available | No information available | No information available |

References: (Sony, 2010), (Sony, 2011), (Samsung Electronics Nordic AB, n.d.), (Samsung, 2011), (Philips 2010) and (Philips 2011).

# Comparison of Currently Available Technologies, Implementing Measures and Ecolabels

Table c.1 Standby and Off-mode power consumption of currently available TVs not awarded an ecolabel compared to the requirements of the EuP Directive and ecolabels.

| | **Implementing Measures** | **European Ecolabel ver. 4.0 and 5.0** | **Nordic Ecolabel** | **Energy Star** | **TCO'06** | **Samsung LCD and Plasma** | **Sony 40" and 46"** | **LG** | **Grundig** | **Panasonic** | **Bang & Olufsen** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Off-mode tier 1** | Compliance in 2010: ≤ 1,00 W | | | | | No information available | No information available | No information available | No information available | No information available | No information available |
| **Off mode tier 2** | Compliance in 2011:<br>≤ 0,5 W if the TV has an easily visible off switch putting the TV in off-mode using ≤ 0,01 W<br>Otherwise: ≤ 0,3 W | | | | | No information available | No information available | No information available | No information available | No information available | No information available |

| | Implementing Measures | European Ecolabel ver. 4.0 and 5.0 | Nordic Ecolabel | Energy Star | TCO'06 | Samsung LCD and Plasma | Sony 40" and 46" | LG | Grundig | Panasonic | Bang & Olufsen |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Off mode** | TVs shall have an off-mode and/or standby-mode, and/or another condition which does not exceed the applicable power consumption requirements for off-mode and/or standby-mode when the TV is connected to the mains power source. | | All products shall have a clearly visible on-off switch | | | No information available | No information available | No information available | No information available | No information available | No information available |
| **Passive standby tier 1** | Compliance in 2010: ≤ 1,00 W ≤ 2,00 W if the TV is providing information or status display | ≤ 0,50 W if energy consumption in off mode < 0,01 W All other equipment: ≤0,3 W | ≤ 0,50 W if energy consumption in off mode < 0,01 W All other equipment: ≤0,3 W | sleep mode: ≤ 1 W | ≤ 1W | < 0.3 W | 0.45 W (screen) 3.4 W (Media receiver) | 1 W | < 1 W < 0.1 W (Vision Eco) | 0.3-0.45 W | 0.8-1 W |
| **Passive standby tier 2** | Compliance in 2011: ≤ 0,50 W ≤ 1,00 W if the TV is providing | | | | | < 0.3 W | 0.45 W (screen) 3.4 W (Media | 1 W | < 1 W < 0.1 W (Vision Eco) | 0.3-0.45 W | 0.8-1 W |

| | Implementing Measures | European Ecolabel ver. 4.0 and 5.0 | Nordic Ecolabel | Energy Star | TCO'06 | Samsung LCD and Plasma | Sony 40" and 46" | LG | Grundig | Panasonic | Bang & Olufsen |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | information or status display | | | | | | receiver) | | | | |
| **Passive standby** | For TV sets which consist of a display, and one or more tuner(s)/receiver(s) and optional additional functions for data storage and/or display such as digital versatile disc (DVD), hard disk drive (HDD) or videocassette recorder (VCR) in one or more separate units, points (a) to (c) apply for the display and the separate unit(s) individually | | | | | | | | | | |

| | Implementing Measures | European Ecolabel ver. 4.0 and 5.0 | Nordic Ecolabel | Energy Star | TCO'06 | Samsung LCD and Plasma | Sony 40" and 46" | LG | Grundig | Panasonic | Bang & Olufsen |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Active standby low tier 1** | | | | Additional: 01.05.2010 $\leq$ 0.08 kWh/day | | No information available | No information available | No information available | No information available | No information available | No information available |
| **Active standby low tier 2** | | | | Additional: 01.05.2012 $\leq$ 0.02 kWh/day | | No information available | No information available | No information available | No information available | No information available | No information available |
| **Automatic power down** | Compliance in 2011:<br>After no more than 4 hours in on mode following the last user interaction and/or a channel change, the<br>TVs shall be automatically switched from on mode to:<br>— standby-mode, or,<br>— off-mode, or,<br>— another condition which does not exceed the applicable | | | | | No information available | No information available | No information available | No information available | No information available | No information available |

| | Implementing Measures | European Ecolabel ver. 4.0 and 5.0 | Nordic Ecolabel | Energy Star | TCO'06 | Samsung LCD and Plasma | Sony 40" and 46" | LG | Grundig | Panasonic | Bang & Olufsen |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | power consumption requirements for off-mode and/or standby-mode | | | | | | | | | | |
| | TVs shall display an alert message before the automatic switch from on mode to the applicable condition/modes. This function shall be set as default. | | | | | No information available | No information available | No information available | No information available | No information available | No information available |
| **Home-Mode** | TVs with forced menu on initial activation of the television shall provide a 'home-mode' in the forced menu, which shall be the default choice on initial activation of | | | | | No information available | No information available | No information available | No information available | No information available | No information available |

| | Implementing Measures | European Ecolabel ver. 4.0 and 5.0 | Nordic Ecolabel | Energy Star | TCO'06 | Samsung LCD and Plasma | Sony 40" and 46" | LG | Grundig | Panasonic | Bang & Olufsen |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | the TV. If the user selects a mode other than 'home mode' on initial activation of the TV, a second selection process shall be prompted to confirm this choice. | | | | | | | | | | |

References: (LG Electronics, 2010), (Grundig, 2010a), (Grundig, 2010b), (Panasonic Europe Ltd, 2010), (Sony, 2010), (Samsung, 2010) and (Bang & Olufsen, 2010)

**Summary**

**English**

The focus of this report is the implementation of the EU Directive 2005/32/EC on ecodesign requirements for energy using products (the EuP Directive) with special attention to the ecodesign requirements for televisions (TV). The aim is to investigate the scope of the Implementing Measures (IM), how ambitious the requirements of the IM are, and to what degree they can promote eco-innovations of TVs.

It is concluded that the potential of the EuP Directive has not been fully realized, since only requirements related to energy efficiency in the use phase have been set up, while other improvement potentials based on an ecodesign rationale have been neglected.

**Danish**

Denne rapport omhandler implementeringen af EU Direktiv 2005/323/EF om rammerne om fastlæggelse af krav til miljøvenligt design af energiforbrugende produkter (EuP Direktivet), med særlig vægt på miljøkravene til fjernsyn. Målet er at undersøge gennemførelsesforanstaltningernes rækkevidde, hvor ambitiøse gennemførelsesforanstaltningerne (IM) er og i hvilken grad de vil promovere miljøvenlig innovation.

Det konkluderes bl.a., at potentialet i EuP direktivet ikke er blevet udfoldet fuldt ud, idet der kun er opstillet energieffektivitetskrav relateret til brugsfasen, mens andre forbedringspotentialer ud fra et eco-design rationale er blevet negligeret.

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# Appendix C. Conference Papers

This appendix contains three conference papers. The first two were presented at the 5th Going Green – CARE INNOVATION 2010 conference, which took place from November 8-11, 2010 in the Schoenbrunn Palace Conference Centre in Vienna, Austria. Details about the conference and the conference proceedings are available here: http://www.care-electronics.net/CI2010/. The third conference paper was presented at the 6th International Conference EEDAL'11 Energy Efficiency in Domestic Appliances and Lighting, which took place from May 24-26, 2011 in Copenhagen, Denmark. Details about the conference and the conference proceedings are available here: http://www.eedal.dk/.

## C.1. Ecodesign – How to unfold the potential synergy between the EuP, WEEE and RoHS Directives

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**Abstract**: The amount, complexity and variety of products introduced to the European market are increasing and products are more than ever traded globally. This development challenges the approach to regulate and stimulate the innovation of cleaner products. The EU has responded by introducing Integrated Product Policy (IPP). The approach aims at promoting measures to reduce the environmental impacts of products. Since the IPP approach was introduced around 2000, several instruments have been implemented; the RoHS, WEEE and the EuP Directive as well as the European ecolabel and the Energy labelling Directive. The focus of this paper is the potential synergy between the three normative, so-called eco-design directives, and to what extent the EU has accomplished to integrate eco-design in the different directives and voluntary instruments.

### 1. INTRODUCTION

Today more than ever we have electronic products everywhere in our households. The quantity is increasing; and it is common to have a TV not only in the living room, but also in the bedroom, the kitchen and even in the children’s rooms. According to the Danish Energy Agency the number of TVs in Danish households has grown from around 2.2 million in 1980 to 5.5 million in 2008 [1]. That equals a growth from approximately 1 TV per household in 1980 to around one per person in 2008. Also the variety of products is increasing; on the ICT side we see families with TV, DVD player, Xbox, Play Station or Wii, PC, laptop, fixed line phone, several mobile phones and the list could go on. With this amount of products the environmental impact of a hold cannot be traced back to one or two major contributors or products but it is spread out on many different products.

The products are also getting more complex both in terms of their function and the technique inside the product, but also in terms of their product chain and the stakeholders involved in the products' life time. A product might be sold in Denmark, but it is produced in South Korea with suppliers and sub-suppliers from China, Malaysia and Singapore delivering parts to the final product. Once the product is broken or the consumer simply finds it out of fashion it is thrown out – hopefully in a way so it can be disassembled, materials reused and toxic substances destroyed properly. Unfortunately, it is seen that loads of old ICT equipment end up in scrap yards in India or Africa, where they are disassembled in a way being a danger both to the environment and the health of people.

**1.1. Integrated Product Policy**

This development has challenged the approach to regulate and stimulate the innovation of cleaner products. EU has responded to this development by introducing the Integrated Product Policy (IPP). IPP was developed in cooperation between the Commission and stakeholders and was first discussed in 1998 [2]. IPP is based on several key principles, first of all Life Cycle that means considering the entire product life cycle from the extraction of raw materials, production, transport, use, recycling and disposal. This aims at considering both the cumulative environmental impacts and avoiding burden shifting, where environmental impacts in a single life cycle phases are addressed with the result of increasing the environmental impact in another life cycle phase. IPP is an integrated approach aiming at promoting

measures to reduce the environmental impact of products at a point where this is most effective [2]. This approach could also be called ecodesign.

Further key principles of IPP are "working with the market", "stakeholder involvement", "continuous improvement" and "a variety of policy instruments". [2]

**1.2 IPP Instruments**

Since the introduction of IPP several legislations implementing the approach have appeared. Especially the following five are relevant in this context:

- Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS)
- Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)

- Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products (EuP)
- Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU Ecolabel
- Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products

Each of the regulations have implemented IPP in their own way. The hypothesis in this paper is that the potential synergy between the ecodesign directives and the energy and ecolabels is not utilized and hence the implementation of ecodesign in the EuP Directive is not successful.

The synergy between EU's IPP regulations is analysed in this paper with the aim of investigating to what extent ecodesign is implemented in the different directives. First, an in depth analysis of the EuP Directive and its potential to implement ecodesign is presented. Thereafter, analyses on how ecodesign is implemented in the RoHS and WEEE Directives are presented. Analyses of EU's ecolabel and the forthcoming energy label are presented and finally the synergy between the two types of IPP instruments is analysed. Throughout the paper the requirements for televisions will be used to exemplify.

## 2. RESULTS

### 2.1 The EuP Directive

The EuP Directive establishes a framework for setting ecodesign requirements for energy using and energy related products. The ecodesign requirements are set up in implementing measures (IM). The objective of the Directive is to ensure free movement on the market of products in compliance with the ecodesign requirements and "*it contributes to sustainable development by increasing energy efficiency and the level of protection of the environment, while at the same time increasing the security of the energy supply*" [3].

The implementation of the Directive indicates that focus in the IM is towards only setting requirements for the energy consumption and energy efficiency. The argument for focusing solely on power consumption is presented in the comments to the Regulation. It is argued that environmental impacts related to hazardous substances in the TVs and waste from disposed TVs are addressed in the RoHS and WEEE Directive, respectively. In Table 1 the focus areas of the nine IM that have been adopted so far are listed. It is clear that focus is not on an integrated thinking as the concept of ecodesign and IPP is all about. The EuP Directive does however have the potential to implement ecodesign, if not only the area with THE most important environmental impact is addressed and if more generic requirements are set up.

**2.2 The RoHS Directive**

The RoHS Directive restricts the use of certain chemical substances in electronic and electrical equipment. The restriction concerns cadmium, lead, mercury, hexavalent chromium, poly-brominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE), in quantities exceeding maximum concentration values. While there is no direct formulation on ecodesign, the aim of the Directive is in this way "*to contribute to the protection of human health and the environmentally sound recovery and disposal of waste electrical and electronic equipment*" [4]. If electrical and electronic products do not comply with the regulation the products are prohibited from being sold on the EU market [5].
According to the Commission the RoHS Directive has prevented several thousand tonnes of the prohibited substances from being placed in the products. Furthermore, design practices in this regard have changed also in countries outside the EU. However, compliance checks in EU member states have revealed that up to 44% of the EEE that was checked for compliance does still not comply with the Directive. [6]

**2.3 The WEEE Directive**

The WEEE Directive sets marking requirements to producers and importers and aims to establish an individual producer responsibility for the take back and treatment of WEEE. The latter makes the producer economically responsible for the take back and environmentally friendly treatment of WEEE. The producer can comply with this regulation individually or by joining collective schemes. The WEEE directive also sets requirements as to the recovery rates of the products in scope. The purpose of the WEEE Directive is, "*as a first priority, the prevention of waste electrical and electronic equipment (WEEE), and in addition, the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste. It also seeks to improve the environmental performance of all operators involved in the life cycle of electrical and electronic equipment, e.g. producers, distributors and consumers and in particular those operators directly involved in the treatment of waste electrical and electronic equipment*" [7].

The idea behind the regulation is that by making the producer responsible for the end of life phase of their products, gives economic incentives for the producer to integrate considerations about the product's end of life phase and recycling options in the design phase. In Article 4 of the Directive it says: "*Member States shall encourage the design and production of electrical and electronic equipment which take into account and facilitate dismantling* *and recovery, in particular the reuse and recycling of WEEE, their components and materials.*" [7]

A recent study has revealed that only seven member states have fully implemented the individual producer responsibility and seven member states have ignored the implementation of the individual producer responsibility completely [8]. In the latter countries the producers can join collective schemes, where they are not financially responsible for the take back of exactly their products, but the payments are based on averages. In these member states the incentives for ecodesign have diminished significantly, and it is questionable whether the WEEE Directive serves its purpose on ecodesign at all.

**2.4 The Flower**

The Flower is the European ecolabel established in 1992. A large range of products can be awarded the ecolabel from campsite services to paint and refrigerators. In this paper the requirements for TVs are investigated further.

The latest Commission Decision on establishing the revised ecological criteria for the award of the Community Ecolabel to TVs was published in March 2009 and focuses on the following areas [9]:

- Power consumption in on-mode
- Power consumption in standby
- Maximum energy consumption
- Dismantling
- Life-time extension
- Chemicals in products
- Information requirements

From the above list it is clear that the Flower expands the focus of requirements compared to the EuP Directive. Besides setting criteria to the energy consumption in the use phase, criteria are set to other life cycle stages and other types of environmental impacts.

Since the introduction of the label the number of labelled products and services has grown steadily. In the beginning of 2010 1064 licences were awarded, 6 of these to TVs. [10]

**2.5 The Energy Labelling Directive**

The first energy labelling Directive was adopted in 1992. The Directive sets a framework for mandatory energy labelling requirements for household appliances, such as refrigerators and washing machines. In 2010 a revision of the Directive was adopted which includes energy related products in the scope [11].

As in the EuP Directive the requirements of the Energy Labelling Directive are set up in IM. To exemplify the IM for TVs is used. The following analysis is of the latest working document put forward in February 2010 [12].

The labelling requirements proposed are that televisions placed on the

European market must be supplied with a label with the following information:

1. the energy efficiency class
2. the on-mode power consumption and the annual on-mode energy consumption
3. the screen size in diagonal

Obviously, the label focuses only on energy efficiency, and quite in line with the EuP Directive. The intention is that the criteria for labelling shall be gradually tightened, meaning that for the label applicable 12 months after the publication of the IM the most energy efficient label possible to obtain is A. From 2013 it will be possible to obtain the label A+ and the F will be the least efficient label. In 2016 A++ will be the most efficient label and E will be the least efficient label. Finally in 2019 the most efficient label is A+++ and E will be the least efficient label. [12]

In Figure 1 the requirements to on-mode power consumption of the EuP Directive, the Flower and the Energy labelling Directive is illustrated. As the Energy labelling Directive works with an energy efficiency index which is divided in intervals, the lines in Figure 1 represent the maximum power consumption the products must have in order to obtain the given label. As an example, in order for the product to obtain the energy efficiency label A+ the product must have a power consumption that is between the A+ line and the A++ line.

### 2.6 The Synergy between IPP Instruments

Two results can be concluded from the above;

- The synergy between the different IPP instruments can be improved
- The synergy between the EuP, WEEE and RoHS Directives can be improved.

Five IPP instruments are presented above. Four of the instruments are mandatory, that is the EuP, RoHS, WEEE and Energy labelling Directives and the Flower ecolabel is voluntary, but where the first three set minimum requirements that expels the worst performing products from the market, the Energy labelling Directive aims at giving the producers incentives to produce better performing products. The Ecolabelling Directive also aims at creating incentives for producers to produce better performing products, but on a voluntary basis.

In Figure 2 the aim of the different IPP instruments is illustrated. RoHS and EuP directives set minimum standards for products' environmental performance, thereby removing the worst performing products from the market. In the other end of the scale, ecolabels set voluntary criteria with the aim that only the best performing products on the market can fulfil. The ecolabels are continuously updated and tightened to ensure that at any time only the best performing products can fulfil the criteria. In this way the ecolabels can generate changes in the market that can create a pull towards more environmentally friendly products.

It is recognized that the directives and the ecolabels are two different approaches to IPP, cf. Figure 2. However, as the IM of the EuP Directive have not accomplished to set comprehensive requirements in terms of fulfilling the aim of ecodesign, it is clear that the obvious link between the ecolabel and the IM have not been utilized.

Many years of work and experience is behind the ecolabels with setting environmental criteria for products and the hot spots of a products environmental performance are the background for these criteria. By creating a common information platform between the several instruments this knowledge could have been utilized and have led to a faster and more comprehensive implementation of the EuP Directive by including more environmental impacts categories in the scope of the IM and in tightening the requirements in the IM. This type of synergy is visible when considering the proposal for IM of the Energy labelling Directive. The energy efficient index determining the label applied to TV fits for some of the categories to both the Flower and the IM of the EuP Directive.

**2.7 The Synergy between EuP, WEEE and RoHS Directives**

It is a balance on the one hand to develop regulations that regulate the environmental impacts of products in a life cycle perspective and on the other side not create inexpedient double regulation that confuses producers, consumers and regulators. However, the objective of the EuP Directive can not be fulfilled without looking at the entire product life cycle and setting requirements to several environmental impact categories.

Especially, the WEEE Directive does not fully fulfil its objective of ecodesign, and it is possible to set specific requirements on design for recycling, material use, etc. as part of the EuP IM without conflicting with the WEEE Directive (since WEEE does not set such requirements). The RoHS Directive has to some degree fulfilled its objectives, but improvements can be made. Chemical requirements in the EuP IM could be an information obligation on the product’s content of Substances of Very High Concern (SVHC) of the candidate list in the REACH Regulation.

As the existing regulation only to a limited degree fulfil their objectives on ecodesign, the EuP directive could without compromising other regulations encompass requirements on the environmental impact of the entire life cycle of the products. It is likely that requirements in three different directives creates confusion and lack of coherency – and one way to avoid “double regulation” is obviously to gather directives with the same overall objective – ecodesign –

in a common Directive. In spite of our criticism of the current processes and content of the IM, then the EuP directive is significantly more on the right track and is more dynamic than what can be said related to ROHS (that just has been recast without significant changes) and WEEE that fails on the ecodesign dimension. Besides, a further benefit is that it will create clarity among regulators, producers and consumers, and the manufacturers will only have one "door" to consider – in long run the generic requirements of the EuP Directive could be a guidebook on ecodesign and on how enterprises can develop cleaner products.

## 3. DISCUSSION

The EuP Directive has not achieved to implement ecodesign in the IM as the main focus is on energy consumption in the use phase. Taking the two other IPP directives into consideration, the RoHS and WEEE Directive, the picture does not change much. Looking at the criteria for TVs of the European ecolabel, the Flower, more environmental aspects are included and the criteria set up for on-mode power consumption are stricter. Therefore two conclusions can be drawn:

1. It is time to create a synergy between the IPP directives and the European ecolabels and thereby utilize the knowledge that already exist on environmental hotspots for the different products groups. For instance by introducing a common information platform. A further benefit besides knowledge and experience sharing is that a common information platform will reduce the preparation time necessary when developing new requirements.

The solution to integrating ecodesign better could be to convert the EuP Directive into THE ONE ecodesign directive as it was the intension from the beginning. This means including more environmental aspects and life cycle phases into the requirements instead of in the directive to refer to other directives that do not include the issue after all.

*Table 1: Focus area of the nine adopted IM of the EuP Directive [13, 14, 15, 16, 17, 18, 19, 20, 21]*

| | Entry into force | Adopted | Power consumption | Energy efficiency | Lamp efficacy | Performance | Motor efficiency | Information requirements |
|---|---|---|---|---|---|---|---|---|
| **Television** | 12.08.09 | 22.07.09 | | | | | | |
| **Standby and off-mode losses** | 07.01.09 | 17.12.08 | | | | | | |
| **Battery chargers and external power supplies** | 27.04.09 | 07.04.09 | | | | | | |
| **Tertiary lighting** | 13.04.09 | 18.03.09 | | | | | | |
| **Simple set-top boxes** | 25.02.09 | 04.02.09 | | | | | | |
| **Domestic lighting** | 18.03.09 | 14.04.09 | | | | | | |
| **Electric motors** | 12.08.09 | 22.07.09 | | | | | | |
| **Circulators** | 12.08.09 | 22.07.09 | | | | | | |
| **Domestic refrigeration** | 12.08.09 | 22.07.09 | | | | | | |

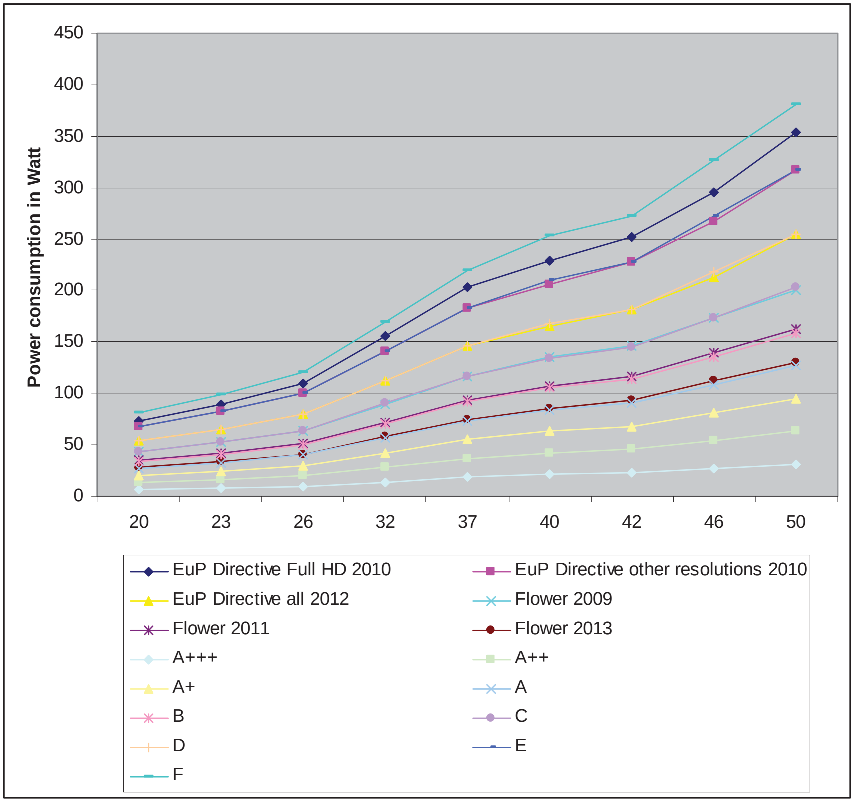


*Figure 1: On-mode power consumption requirements of the IM of the EuP Directive, the Flower ecolabel and the forthcoming energy label for TVs.*

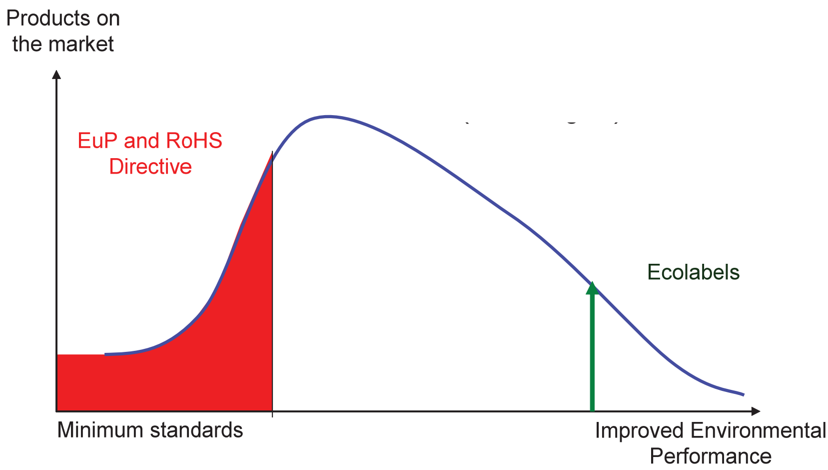


*Figure 2: The scope of the EuP and RoHS Directives compared to the scope of the Ecolabels*

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# C.2. energy efficient televisions – Technology push or regulatory pull?

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**Abstract**: The EuP Directive sets the frame for implementing ecodesign requirements for energy-using and energy-related products. The aim of the Directive is to achieve a high level of protection for the environment by reducing the potential environmental impact of energy-related products. The focus of this paper is on the Implementing Measures (IM) for televisions. The ambition level of the IM for televisions is investigated and it is argued that the IM have not succeeded in setting up sufficient ecodesign requirements, as only one life cycle phase and one environmental impact category is addressed. Furthermore, a comparative analysis of best available technology and conventional technologies implies that the standard for the environmental performance of TVs has been driven by technology push rather than a regulatory pull.

## 1. INTRODUCTION

Climate change, increases in energy consumption, global product chains, and shorter innovation cycles of new technologies and products, etc. are several of the challenges that single countries and the European Union (EU) have tried to address in order to increase the focus on development of more energy and resource efficient products.

A response to these trends from the EU has for 10 years now been the Integrated Product Policy (IPP). The IPP toolbox uses numerous instruments both voluntary and mandatory. Several legislations have implemented the approach, latest the EU Directive on ecodesign requirements for energy-using products (Directive 2005/32/EC) and for energy-related products (Directive 2009/125/EC) The objective of the directives is to contribute *to sustainable development by increasing energy efficiency and the level of protection of the environment, while at the same time increasing the security of the energy supply* [1].

The focus of this paper is the EU Directive 2005/32/EC on ecodesign of energy using products (the EuP Directive) with special attention to the ecodesign requirements for televisions (TV). The aim is to investigate the scope of the Implementing Measures (IM), how ambitious the requirements are, and to what degree they can promote eco-innovation of TVs. First a definition of ecodesign is given, which serves as a realm of understanding what the IM is supposed to achieve. The results of three analyses are presented; 1) a comparison of the IM with the ecolabels, 2) an analysis of the performance of best available technologies (BAT) and the requirements of IM and ecolabels, and 3) a comparative assessment of the performance of conventional technologies and the requirements of IM and ecolabels.

## 2. METHODS

The study is based on a literature review of the EuP Directive and four ecolabels; The Flower, The Nordic Ecolabel, Energy Star and TCO'06 [2, 3, 4, 5]. Information on power consumption of the TVs in the study has been gathered on the webpages of the producers. The TVs investigated were randomly selected and represent different screen sizes and technologies. TVs from the following brands were investigated:

- Samsung [6, 7]
- Sony [8]
- Panasonic [9]
- LG [10]
- Grundig [11, 12]
- Bang & Olufsen [13]

The investigation of the performance of BAT and conventional technologies was performed in the winter 2009/2010.

## 3. RESULTS

Before presenting the results of the analyses, a definition of the term ecodesign is necessary in order to understand the scientific meaning of ecodesign.

### 3.1 Ecodesign

Basically, ecodesign means environmentally conscious product development. Other similar concepts are Design for the Environment and Design for Sustainability [14, 15, 16, 17, 18, 19, 20]. In practice it implies that environmental considerations are integrated with the other considerations when developing products including functional, economic, safety and quality issues. Eco-design focuses on all possible areas of improvements in the product's entire life cycle, from the definition of the function, over selection of raw materials, production methods and transport means, to how the use, recycling and disposal is organised. All relevant environmental properties should be addressed, including material and energy efficiency, emissions and hazardous substances. The aim of ecodesign is to fulfil a need with the least environmental impact, meaning that the function of the product should be the point of departure for future product development [14].

### 3.2 Comparison of IM and Ecolabels

With the above definition of ecodesign in mind, the scope and level of ambitions of the IM for TVs will be analysed. The IM are compared to four ecolabels. The rationale is twofold; first of all are ecolabels acknowledged by authorities, consumers and producers. Secondly, many years of experience and work lie behind the ecolabels, and the products fulfilling the criteria of eco-labels are considered among the best environmentally performing product in their category without compromising the quality. All ecolabels except the Energy Star consider the entire life cycle of the product and hence are in line with the definition of ecodesign.

In Table 1 the focus areas of the IM and the ecolabels are compared. The narrow focus of the IM on energy consumption in the use phase becomes clear. All ecolabels except the Energy Star focus on general ecodesign requirements, dismantling, life time extension and chemicals, thereby setting requirements to several phases of the products life cycle and to more impact categories. Taking a closer look at the energy requirements on on-mode power consumption, it is evident that the requirements of the IM are not as strict as the ecolabels, see Figure 1. The IM requirements for full HD are for example 1.7 times larger than the Flower requirements for 2009. The IM requirements for 2012 are more than 1.5 times larger than the Flower requirements for 2011. Furthermore, the IM requirements do not set an upper limit for maximum on-mode power consumption, thereby accepting the connection between screen size and power consumption. This is questionable since the trend is towards bigger and bigger screens, with most likely higher power consumption. Both the Nordic and the EU Flower ecolabels have considered this and set a maximum on-mode power consumption of 200W regardless of screen size. With regards to the standby and off-mode requirements, however, the IM requirements fit approximately with the requirements of the ecolabels, see Figure 2.

### 3.3 Achievements of BAT

After having investigated the ambition level of the IM, the market for current technological trends and possibilities is now analysed. First, the best available technologies (BAT) are investigated. Especially two technologies have a significant positive influence on the environmental impact of TVs; Light Emitting Diodes (LED) and Hot Cathode Fluorescent Lamp (HCFL). These technologies are used by Samsung and Sony respectively. Besides, the efficient backlight technologies Sony has installed a number of features that helps reduce the power consumption even further. These are a presence sensor that detects movement and body heat, and a light censor, which registers the light in the room and adjust the backlight of the TV accordingly. All investigated TV based on the new technologies are labelled with the Nordic Ecolabel. In Figure 1 the BAT is compared to the requirements of the IM and ecolabels.

It is obvious that the TVs based on these new technologies perform significantly better than what is required by the IM, some of the TVs even comply with the Flower requirements of 2013. Is this performance compared to the preparatory studies of the IM, these new technologies were not even mentioned in the study, hence not having an impact on setting up the requirements. However, this is not a surprise as the LED technology was not on the market, when the preparatory studies began. In other words, the process of EuP takes too long in the case of televisions, and furthermore the innovation of new televisions is more driven by a technology push rather than a regulatory pull leading to an improved environmental performance.

### 3.4 Achievements of Conventional Technologies

The same analysis is made for TVs based on conventional technologies as they are expected to have the most difficulties complying with the requirements of the EuP Directive, see Figure 3. The result is that 32 of the 35 investigated TVs can comply with the IM requirements from August 2010, whereof 16 can comply with the 2012 requirements. That so many TVs already can comply with the IM requirements, before they step into force, indicates that the requirements of EuP have not been too ambitious. Of course it may have had an influence that the investigation for this paper was performed nearly six months before the requirements steps into force, meaning that the producers have already prepared their products for the forthcoming requirements.

With regards to standby power consumption, four of the six brands have TVs which can comply with the IM requirements for 2011, and all TVs can comply with the requirements that stepped into force January 2010. However, this is not a surprise since the standby requirements had stepped into force by the time of the investigation.

## 4. DISCUSSION

As shown, the requirements of the IM are first of all *narrower in scope* than what should be expected as the directive aims at ecodesign. A strict focus on energy consumption in the use phase is just one single phase and just one environmental aspect – compared to the comprehensive focus on all potential improvements of the product in ecodesign.

The IM requirements are also narrower than the ecolabels that have set up criteria for important environmental aspects of a television. Obviously, the most important environmental impact stems from energy consumption in the use phase, which is not surprising for energy using products. However, why just consider requirements to energy efficiency, when other types of minimum demands could have been set up to resource efficiency, recyclability, etc.? A broader focus on all areas of improvement would have been in line with ecodesign and ecolabels.

Furthermore, as shown the requirements on on-mode power consumption in the IM are less strict than the ecolabels. This is also a consequence of the fact that ecolabels and IM are different IPP instruments that to some degree have different purposes. The IM are minimum requirements and are mandatory for all product sold in the internal market of EU. Ecolabels, on the other hand, are voluntary and have more strict criteria in order for front-runner enterprises to gain a competitive advantage on the market. The aim of the IM is to exclude the worst performing products from the market, whereas the aim of the ecolabels is to create incentives for producers to innovate cleaner products. Even though the IM requirements are not meant to be as strict as the ecolabels it is necessary to discuss how to create the best synergy between the two policy instruments, and how big the difference should be between the IM requirements and the ecolabel criteria.

Further, it should be noticed that new technology has been introduced since the completion of the preparatory study. This means that new energy efficient technologies have not had an influence on the ambition level of the IM. More specifically was the preparatory study launched in February 2006, the final report finished in August 2007 and the first requirements of the IM came into force in January 2010. In the preparatory study it is mentioned that the TVs investigated are based on expected future sales, hence technologies such as Cathode Ray Tubes (CRT) are considered less important for the study. The focus is therefore on Plasma Panel Displays (PDP) and Liquid Crystal Display (LCD). [21] The LED technology, which has had a significant market introduction in 2009, is not mentioned in the preparatory study at all, meaning that this much more energy efficient technology has not been considered when setting up the requirements of the IM. As shown in figure 1, LED technology is much more efficient, and in this case LED has been a technology push rather than the IM being a regulatory pull towards energy efficient technologies.

This raises the question regarding the EuP process; if it is possible to minimise the time span from the launch of the preparatory study to the requirements steps into force – four years is obviously too long when it comes to electronics.

First of all, it seems as a waste of time and resources that the consultants behind the preparatory studies begin from scratch. At least for the product group, where ecolabels already exist, there is materials and studies available on the environmental impacts of the specific product. A common information platform between voluntary and mandatory measures will reduce the preparation time necessary, and could be a way to inspire broader environmental requirements in the IM of EuP.

*Table 1: Focus area of the IM and the ecolabels*

| Subject | Implementing Measures | EU Flower | Nordic Ecolabel | Energy Star | TCO'06 |
|---|---|---|---|---|---|
| Power consumption on-mode | ■ | ■ | ■ | ■ | |
| Power consumption in off-mode | ■ | | ■ | | |
| Power consumption in passive standby | ■ | ■ | ■ | ■ | ■ |
| Power consumption active standby low | | | | ■ | |
| Maximum energy consumption | | ■ | ■ | ■ | |
| General eco-design requirements | | ■ | ■ | | ■ |
| Dismantling | | ■ | ■ | | ■ |
| Life-time extension | | ■ | ■ | | |
| Chemicals in products | | ■ | ■ | | ■ |
| Information requirements | ■ | ■ | ■ | ■ | ■ |
| Environmental Management system | | | | | ■ |

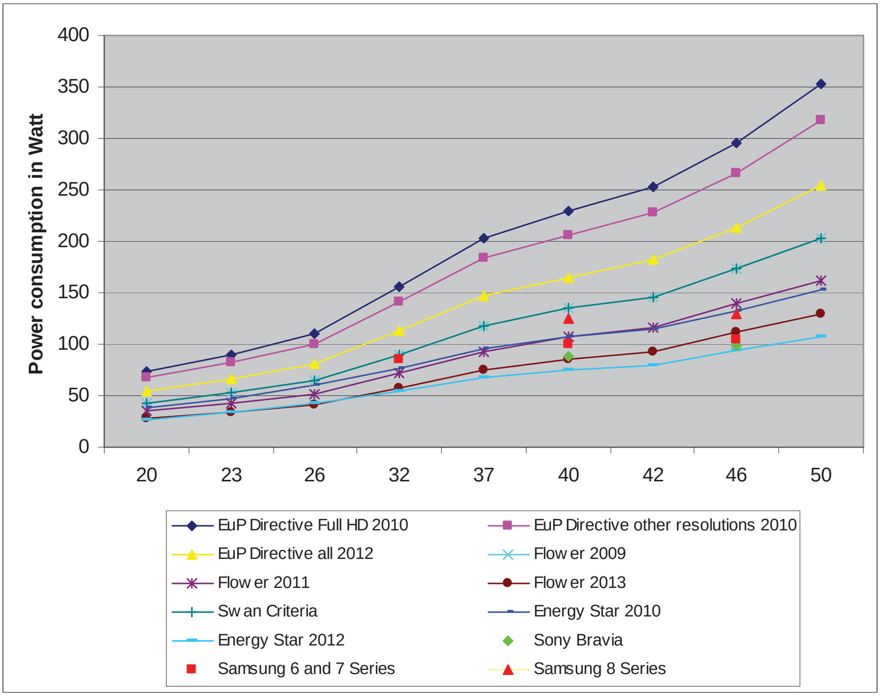


*Figure 1: On-mode power consumption requirements of the IM and the ecolabels, and the on-mode power consumption of BAT from Sony and Samsung.*

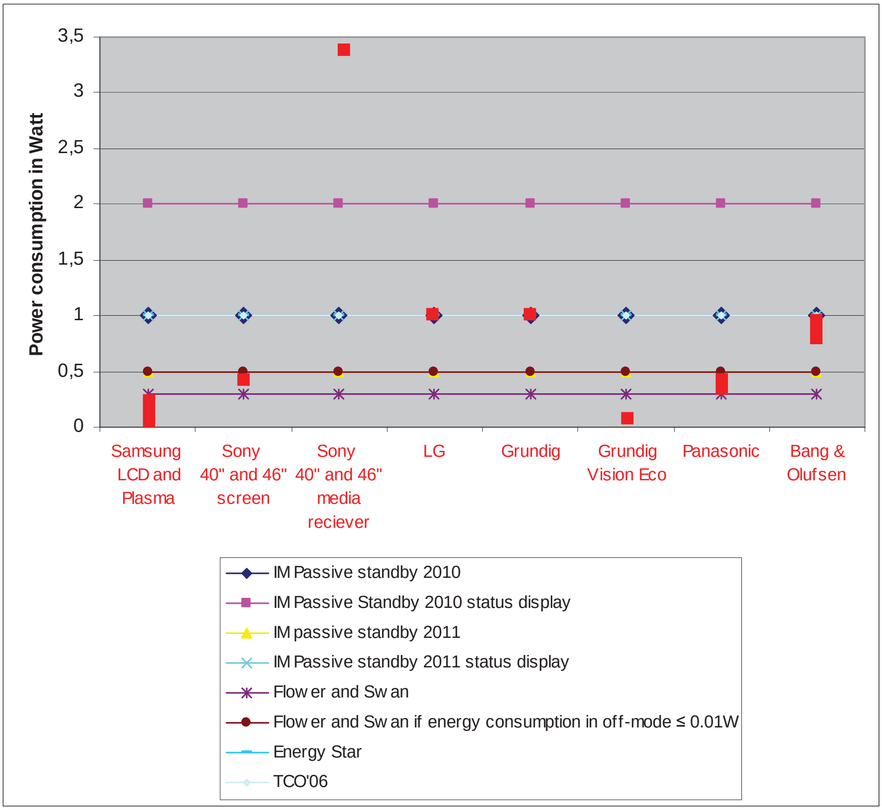


*Figure 2: Standby power consumption requirements of the IM and ecolabels, and the standby power consumption of the BAT TVs investigated.*

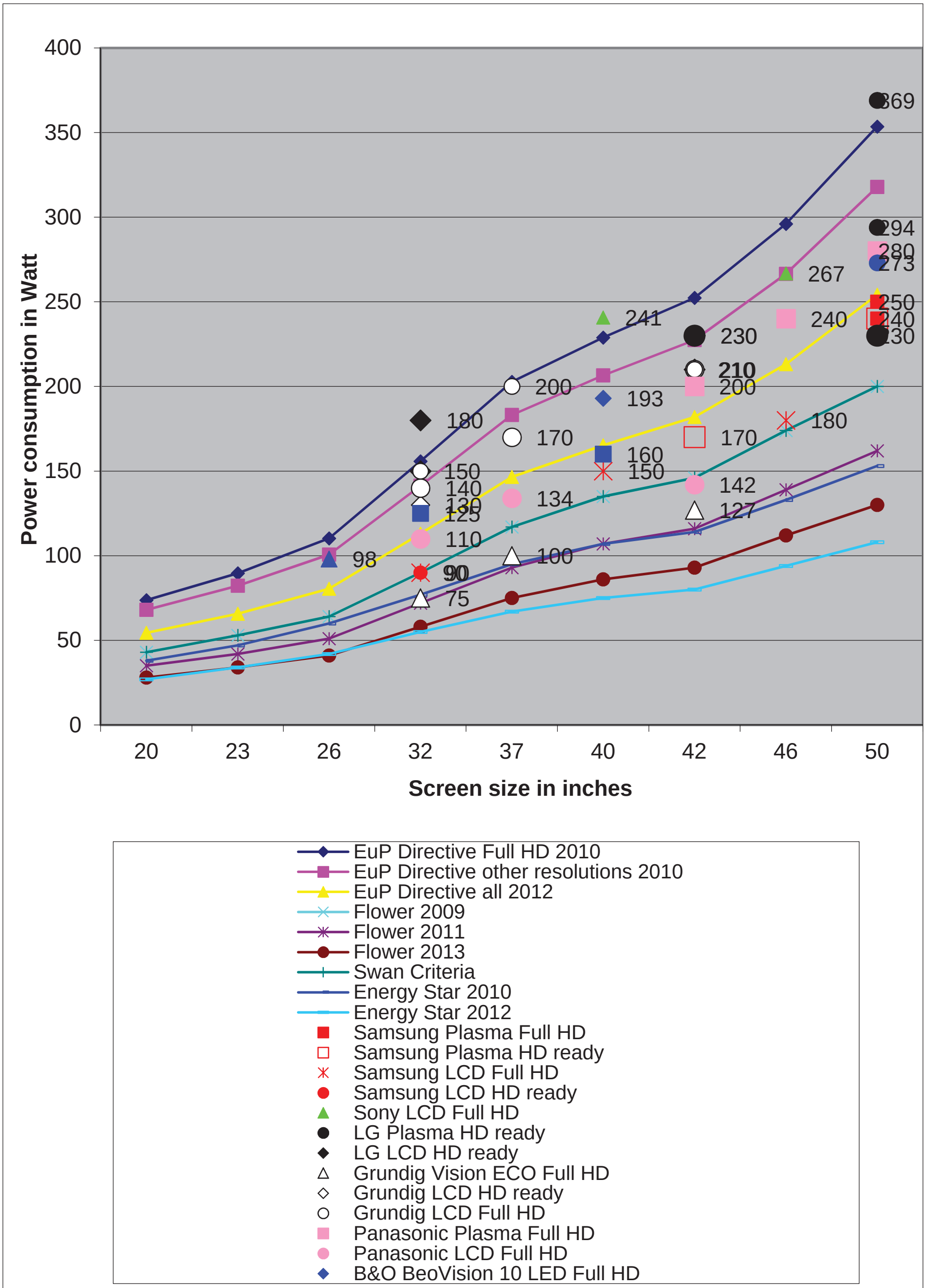


*Figure 3: Comparison of conventional technologies, IM and ecolabels*

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# C.3. Implementing Measures of the Ecodesign Directive – Potentials and Limitations

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**Abstract**: The EU Directive on Energy-related Products (2009/125/EC) sets the frame for implementing ecodesign requirements for energy-using and energy-related products. The aim is to contribute to sustainable development by increasing energy efficiency and the level of environmental protection, while at the same time increasing the security of energy supply. The ecodesign requirements of the Directive are put forward in Implementing Measures (IM) based on comprehensive preparatory studies.

This paper focuses on the experience with the IM so far. In January 2011, eleven IM have been adopted. These IM focus on energy efficiency, power consumption, water consumption, information requirements and in some cases quality and performance issues. All IM only take the use phase of the products life time into consideration.

The ambition level of the IM is analysed through a detailed case study of the IM for televisions. It is argued that the IM have not succeeded in setting up sufficient ecodesign requirements, as only one life cycle phase and mainly one environmental impact category is addressed. The result of an analysis of televisions (TVs) on the market shows that new technologies have been developed that reduce power consumption significantly, and these technologies have been assessed not being mature enough to be included in the IM and the preparatory studies. Hence, it is concluded in this article that the process around the Ecodesign Directive has been too slow to be considered a driver for increasing material and energy efficiency of televisions. Furthermore, it can be concluded that technology development has been a more important driver during the past five years.

## 1. Introduction

In 2005 the EuP Directive (2005/32/EC) was adopted as part of the European Unions Integrated Product Policy (IPP). The directive establishes a framework for setting ecodesign requirements for energy using products. In 2009 the directive was recast, and the new directive (2009/125/EC) also includes energy related products in its scope. Throughout the paper 'Ecodesign Directive' will be used to cover both the initial directive and the recast version.

The requirements of the Ecodesign Directive are set up in implementing measures (IM). The objective of the Directive is to ensure free movement on the market of products in compliance with the ecodesign requirements and '*it contributes to* *sustainable development by increasing energy efficiency and the level of protection of the environment, while at the same time increasing the security of the energy supply*' [1]. The requirements of the IM will be gradually tightened in order to ensure continuous improvement.

In this paper, focus is on the experiences with the IM in the Ecodesign Directive so far. It is in particular analysed how the requirements in the IM fit with the theoretical understanding of ecodesign and the IM for televisions (TV) are analysed more in depth. First, a definition of ecodesign is necessary.

### 1.1 Definition of Ecodesign

Basically, ecodesign means environmentally conscious product development. Other similar concepts are Design for the Environment and Design for Sustainability [2, 3, 4, 5, 6, 7, 8]. In practice it implies that environmental considerations are integrated with the other considerations when developing products including functional, economic, safety and quality issues. Ecodesign focuses on all possible areas of improvements in the product's entire life cycle, from the definition of the function, over selection of raw materials, production methods and transport means, to how the use, recycling and disposal are organised. All relevant environmental properties should be addressed, including material and energy efficiency, emissions and hazardous substances. The aim of ecodesign is to fulfil a need with the least environmental impact, meaning that the function of the product should be the point of departure for future product development [2].

Figure 1 illustrates an ecodesign strategy wheel, developed by Han Brezet and Carolien van Hemel in 1997. The strategy wheel illustrates the steps and strategies that can be followed in ecodesign. The centre of the figure is a spider web illustrating the environmental profile of the product. In this case the blue area illustrates the environmental profile of the old product and the green area illustrates the profile of the new and ecodesigned product.

In the following the adopted IM of the Ecodesign Directive are analysed. In this analysis, we focus on all the life cycle phases and environmental impacts included in the IM. Hereafter, an in depth case study of the IM for televisions (TV) is presented. The focus areas of the IM are compared to the criteria of four ecolabels; the European Ecolabel, the Nordic Ecolabel, Energy Star and TCO'06 for Media Displays. The aim is to investigate which other environmental areas are assessed important by other instruments. The rationale is twofold; first of all, ecolabels are acknowledged by authorities, consumers and producers. Secondly, many years of experience and work are behind the ecolabels. The products fulfilling the criteria of eco-labels are considered among the best environmentally performing product in their category without compromising the quality. All ecolabels except the Energy Star consider the entire life cycle of the product. Consequently, they are in line with the definition of ecodesign. Finally, the performance of TVs on market are investigated and compared to the requirements in the IM.

## 2. Methods

The study is based on a literature review of the Ecodesign Directive, the IM for TV and four ecolabels; The European Ecolabel, The Nordic Ecolabel, Energy Star and TCO'06 [9, 10, 11, 12]. Information concerning the performance of TVs on the market has been gathered on the webpages of the producers. The TVs analysed are considered being the best available technology. TVs from the following brands were analysed:

- Samsung [13, 14, 15]
- Sony [16, 17]
- Philips [18]

## 3. Implementation of the Ecodesign Directive

The status in January 2011 is that eleven IM have been adopted. The first entered into force in January 2009. In Table 1 the focus areas of the eleven IM are listed. It is visible that all IM include either power consumption or energy efficiency in the requirements. The only exception is the IM for electric motors. This IM has a focus on motor efficiency which is also energy related. Five of the eleven IM focus solely on power consumption and/or energy efficiency, which is a high percentage of the IM. Other areas addressed by some of the IM are related to quality and performance issues. The only IM that stands out to some degree is the IM for washing machines, which has included requirements on water consumption in the IM. It is also noteworthy that all requirements are concerned about the use phase only.

Three conclusions can be drawn from this analysis:

1. Not all environmental areas are addressed in the IM, which is in contradiction with the concept of ecodesign as defined above, as all environmental areas should be addressed according to ecodesign.

2. Only one life cycle phase is addressed, which also is in contradiction with the concept of ecodesign, as all life cycle phases should be addressed according to ecodesign.

3. The requirements are in line with the concept of ecodesign when it comes to continuous improvement. As noted above the requirements are gradually tightened to achieve innovation.

According to Article 15, 4. (a) of the Directive the Commission shall, when preparing a draft for IM, '*consider the life cycle of the product and all its significant environmental* *aspects, inter alia, energy efficiency.*' It is in this article assessed that the narrow focus of the IM for TVs is a result of a too narrow interpretation of article 15, 4. (a) and hence only the most important environmental aspect is included in the IM. It can therefore be concluded that the Ecodesign Directive has the potential to regulate more environmental impacts of the products if not only the most important areas are addressed. In the following, four ecolabels are analysed with the aim of analysing which other environmental areas are assessed relevant to regulate by other instruments.

## 4. Implementing Measures for Televisions compared to Ecolabels

In this section the IM for TVs is analysed more in depth. According to the Danish Energy Agency the number of TVs in Danish households has grown rapidly in recent years from around 2.2 million in 1980 to 5.5 million in 2008 [31]. That equals a growth from approximately 1 TV per household in 1980 to around one per person in 2008. This rapid growth underlines the importance of investigating the environmental impact of TVs and set up requirements for TVs.

The focus areas of the IM for TVs and the ecolabels for TVs are compared in Table 2. The narrow focus of the IM for TVs is very clear in this comparison. All ecolabels except the Energy Star focus on general ecodesign criteria, dismantling, lifetime extension and chemicals, thereby setting criteria to several phases of the products' life cycle and to more environmental areas.

Taking a closer look at the energy criteria on on-mode power consumption, it is evident that the requirements of the IM are not as strict as the ecolabels, see Figure 2. The IM requirements for full HD are for example 1.7 times larger than the European Ecolabel criteria for 2009. The IM requirements for 2012 are more than 1.5 times larger than the European Ecolabel criteria for 2011. This is not surprising as they are different types of policy instruments. Ecolabels are meant as an incentive for frontrunner companies, whereas the IM are minimum requirements aiming at excluding the worst performing products from the market. However, the range between the two requirements, especially with the larger screen sizes, is quite big.

Furthermore, the IM requirements do not set an upper limit for maximum on-mode power consumption, thereby accepting the connection between screen size and power consumption. This is problematic since there is a trend towards bigger and bigger screens, with most likely higher power consumption. Both the Nordic and the European ecolabels have considered this and set a maximum on-mode power consumption of 200 Watt regardless of screen size.

## 5. Performance of Televisions on the Market compared to the Implementing Measures

In this section, the on-mode power consumption of televisions on the market is analysed and compared to the requirements of the IM. The aim is to assess the ambition level of the IM. The study was done in the winter of 2009/10 and again in winter/spring 2011. As the requirements entered into force in summer 2010, the study is performed half a year before and after the requirements entered into force.

TVs with ecolabels were first analysed in the study in 2009/10. These were regarded as the best available technologies (BAT). Two technologies have a significant positive influence on the environmental impact of TVs; Light Emitting Diodes (LED), used by Samsung, and Hot Cathode Fluorescent Lamp (HCFL), used by Sony. Besides this technology, Sony has installed a number of features that helps reduce the power consumption even further. These are a presence sensor that detects movement and body heat, and a light censor, which registers the light in the room and adjust the backlight of the TV accordingly. All investigated TVs based on the new technologies are labelled with the European or the Nordic Ecolabel.

For the study in 2011 it was found that the ecolabelled TVs were not necessarily the most energy efficient TVs. Therefore, the TVs with the lowest on-mode power consumption are presented in Figure 2, regardless if they are labelled with an ecolabel or not. The ecolabelled TVs in the study from 2011 are Samsung 32” and 40”, Philips 42” and 46”. These are all labelled with the European Ecolabel.

Figure 2 illustrates the power consumption of ecolabelled TVs from Samsung, Sony and Philips. It is obvious that the TVs based on these new technologies perform better than what is required by the IM, some of the TVs even comply with the Energy Star criteria of 2012, which are the strictest criteria. Since this study was made twice with a year in between Figure 2 also illustrates the development of the power consumption within this year. It is noticeable that in 2009/10 BAT was considered to be ecolabelled TVs. However, in 2011 in several cases for Sony TV the best performing TVs, in terms of power consumption, were not the ones labelled with an ecolabel. This is an interesting result as it could lead to the conclusion that not even the ecolabels can keep up the pace of the technological development

A new technological development in the time between the two studies is the 3D technology. All TVs from Samsung in 2011 have included the 3D technology. As it is illustrated in Figure 2 even the TVs with the new technology are also easily able to comply with the requirements of the IM. A positive development is the 42” TV from Philips, which nearly consumes half the power compared to some of the TVs with a smaller screen size. This TV is also based on the LED technology and has installed different power saving features such as a light sensor and eco mode [18]. Philips TVs were not part of the 2009/10 investigation, consequently a comparison with the older models of Philips is not possible.

In the preparatory studies of the IM the LED technology was mentioned. The consultancy who prepared the preparatory study did however, not find the technology mature enough to be able to draw conclusions on its power consumption level and its environmental impact [28]. It can therefore be assumed that the technology has not had a significant impact on the requirement setting process. This is not a surprise though, as the LED technology was not on the market, when the preparatory studies began. The question is therefore why the technological development in the case of LED has happened so rapidly. Possibly, the industry did develop the technology faster as an attempt to anticipate the coming IM of the Ecodesign Directive or the development would have happened regardless of the adoption of the Ecodesign Directive. The 3D technology has not been mentioned at all in the preparatory study. In both cases the attention is drawn to the time span from the preparatory study, where the analyses are made on possible requirements of the IM and to the time when the requirements step into force. The process is quite complex and long with involvement of all stakeholders, and the technologies in the TVs can develop significantly faster than what is expected in the IM.

## 6. Conclusions

In this paper the IM of the Ecodesign Directive are analysed. In particular how the requirements in the IM fit with the theoretical understanding of ecodesign and how ambitious the requirements are compared to ecolabels and the performance of best available TVs on the market.

The status in January 2011 is that eleven IM have been adopted. Many of the IM have a focus on power consumption or energy efficiency only. Other issues regulated are related to water consumption, performance and quality. A strong tendency is found that only the use phase of the products is included. Compared to the theoretical understanding of ecodesign, three conclusions can be drawn:

1. Not all environmental areas are addressed in the IM, which is in contradiction with the concept of ecodesign as defined above, and by the way, also to the scope of the Directive.

2. Only one life cycle phase is addressed, which also contradict with the concept of ecodesign, as all life cycle phases should be addressed.

3. The requirements are in line with the concept of ecodesign when it comes to continuous improvement. As noted, the requirements are gradually tightened to achieve improvements of performance over time.

The comparison of the IM and the European Ecolabel, the Nordic Ecolabel, Energy Star and TCO’06 shows that the ecolabels are significantly stricter than the IM – as they should be – and they include more environmental areas and product life cycle phases in their criteria. One reason for the narrower scope is that the IM only focus on the most important environmental impact. However, in order for the directive to be in line with the concept of ecodesign it is an imperative that more environmental impacts and life cycle phases are considered.

With regard to the IM being less strict than the ecolabels, this is not surprising as they are different types of policy instruments. Ecolabels are meant as an incentive for frontrunner companies, whereas the IM are minimum requirements aiming at excluding the worst performing products from the market. However, there is a large range between the two requirements, especially with regard to the larger screen sizes. First, the IM simply accept the relation between the screen size and power consumption. The European and the Nordic Ecolabel have dealt with this by setting an upper limit of 200 Watts regardless of screen size. Further, looking at the market tendency towards larger screen sizes and at the performance of the best available TVs these can easily comply with the IM and many of the ecolabels. This raises the question: what impact does the IM have at all if the performance of the TVs is way below the requirements?

The study of the TVs on the market shows that all investigated TVs could comply with the requirements of the IM and many of the ecolabels both in 2009/10 and in 2011. As only TVs including BAT are analysed this result is not a surprise. However, it is surprising how low the power consumption is. The TV producers have applied different technologies to obtain these low power consumption values. Samsung and Philips have used LED as backlight, which was assessed to be an immature technology in the preparatory study. This leads to the conclusion that the environmental improvements of TVs seem to be driven by a technology push rather than a regulatory pull. It could though also be the case that the producers have speeded up the development of the LED technology because of future requirements in the IM – future expectations to regulatory demands as a driver. A new technology applied in 2011 is the 3D TV. Even the TVs with the new technology are still easily able to comply with the requirements of the IM. The 3D technology has not been mentioned at all in the preparatory study. In both cases, a conclusion is that the process of Ecodesign Directive and the IM takes too long in the case of televisions, and furthermore the innovation of new televisions is more driven by technology push rather than regulatory pull leading to an improved environmental performance.

Since this study was made twice with a year in between it is also possible to see the development within this year. It is noticeable that in 2009/10 BAT was considered to be ecolabelled TVs. However, in 2011 in several cases for Sony TVs, the best performing TVs in terms of power consumption were not the ones labelled with an ecolabel. This is an interesting result as it could lead to the conclusion that not even the ecolabels can keep up the pace of the technological development.

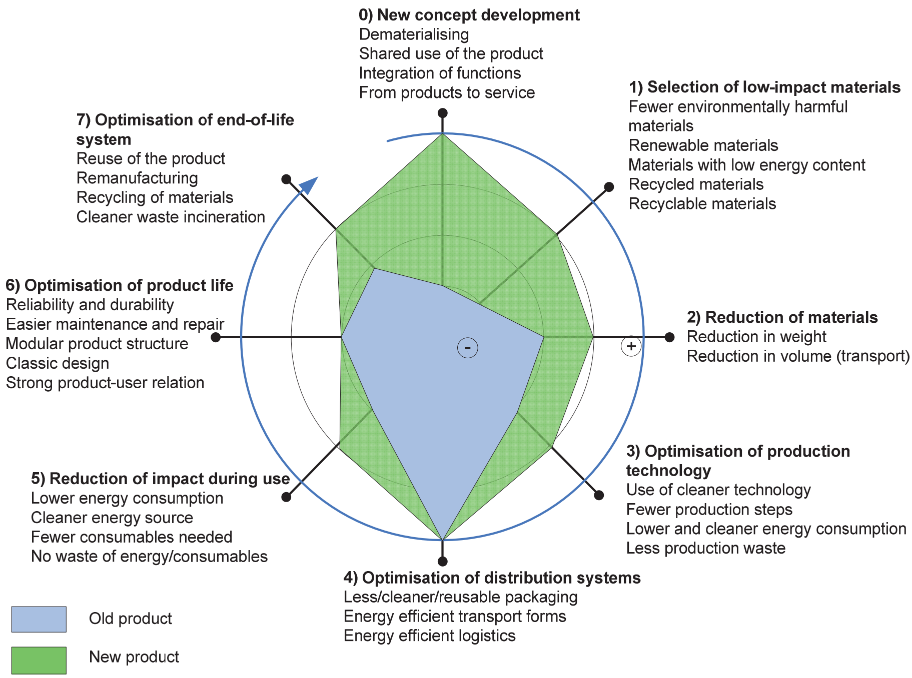


*Figure 1: The ecodesign strategy wheel [4].*

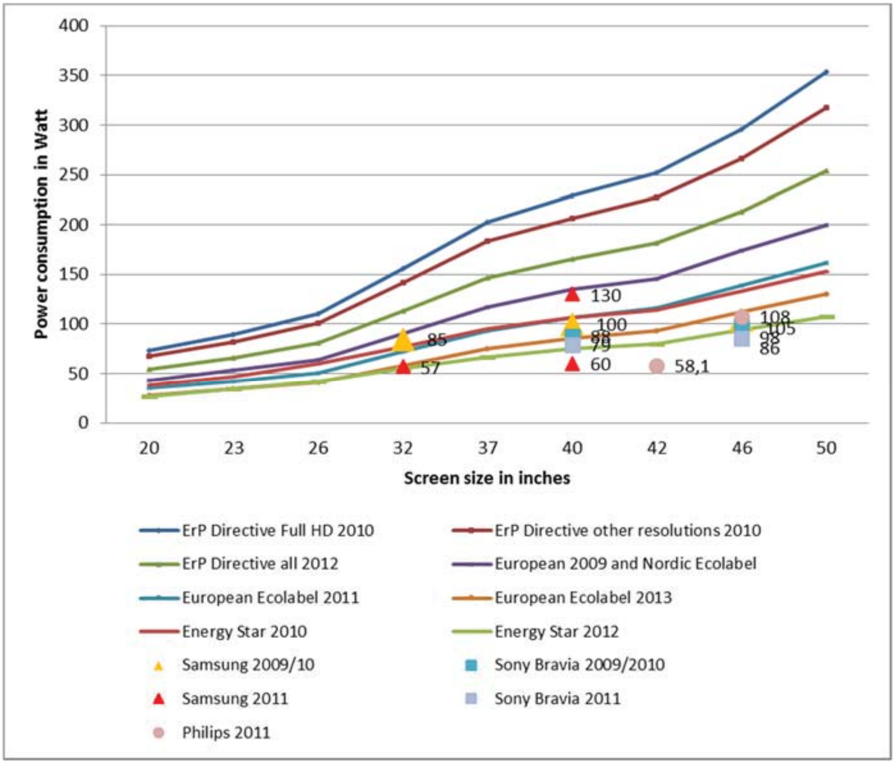


*Figure 2: On-mode power consumption requirements of the IM and the ecolabels for TVs and the power consumption of Samsung, Sony and Philips TVs with the BAT [9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19].*

*Table 1: Focus area of the eleven adopted IM of the Ecodesign Directive [19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30].*

| | **Entry into force** | **Adopted** | **Power consumption** | **Energy efficiency** | **Lamp efficacy** | **Performance** | **Motor efficiency** | **Cleaning efficiency** | **Drying efficiency** | **Washing efficiency** | **Water consumption** | **Washing cycle at 20°** | **Information requirements** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Television** | 12.08.09 | 22.07.09 | | | | | | | | | | | |
| **Standby and off-mode losses** | 07.01.09 | 17.12.08 | | | | | | | | | | | |
| **Battery chargers and external power supplies** | 27.04.09 | 07.04.09 | | | | | | | | | | | |
| **Tertiary lighting** | 13.04.09 | 18.03.09 | | | | | | | | | | | |
| **Simple set-top boxes** | 25.02.09 | 04.02.09 | | | | | | | | | | | |
| **Domestic lighting** | 18.03.09 | 14.04.09 | | | | | | | | | | | |
| **Electric motors** | 12.08.09 | 22.07.09 | | | | | | | | | | | |
| **Circulators** | 12.08.09 | 22.07.09 | | | | | | | | | | | |
| **Domestic refrigeration** | 12.08.09 | 22.07.09 | | | | | | | | | | | |
| **Domestic dishwashers** | 01.12.10 | 10.11.10 | | | | | | | | | | | |
| **Domestic washing machines** | 01.12.10 | 10.11.10 | | | | | | | | | | | |

*Table 2: Focus area of the IM for TVs and the ecolabels for TVs [9, 10, 11, 12, 19]*

| Subject | Implementing Measures | European Ecolabel | Nordic Ecolabel | Energy Star | TCO'06 |
|---|---|---|---|---|---|
| **Power consumption on-mode** | | | | | |
| **Power consumption in off-mode** | | | | | |
| **Power consumption in passive standby** | | | | | |
| **Power consumption active standby low** | | | | | |
| **Maximum energy consumption** | | | | | |
| **General eco-design criteria** | | | | | |
| **Dismantling** | | | | | |
| **Life-time extension** | | | | | |
| **Chemicals in products** | | | | | |
| **Information requirements** | | | | | |
| **Environmental Management system** | | | | | |

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# Appendix D. Policy Instruments aiming at contributing to Sustainable Development

This Appendix contains an introduction and brief analysis of the policy instruments, which are discussed in Chapter 3, and as such, this Appendix provides the background information to the analysis in Chapter 3. The analyses were primarily conducted in the period 2010-2014. Any changes since this period are not included in this appendix.

In the following the aim, scope and achievements of the RoHS, WEEE and Energy Labelling Directive, the REACH Regulation, the European Ecolabel and Green Public Procurement Criteria are analysed. The purpose of the analyses is to assess if the policy instruments serve their purpose. Hence, in the following each of the regulations is briefly presented with the aim of analysing the following points:

- What is the scope and aim of the regulations with regard to environmental improvements of products?
- What are the achievements of the regulations in terms of environmental improvements of products?

The analysis of the regulations is solely based on desk research, analysing the policy documents and available evaluations of the policies. The analyses are as far as possible conducted for all product groups covered by the regulation in order to give the most comprehensive analysis. However, where this has not been possible or the detailed level of an example is necessary, televisions are used to exemplify, as televisions also are used as a case study in Chapter 4 .

## D.1. RoHS Directive

The RoHS Directive restricts the use of certain chemical substances in electronic and electrical equipment. The restriction concerns lead, mercury, hexavalent chromium, poly-brominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE) in quantities exceeding 0.1% and Cadmium in quantities exceeding 0.01%. (European Commission, 2011)

The first version of the Directive, adopted in 2003, covered electrical and electronic products in the categories: Large household appliances, Small household appliances, IT and telecommunications equipment, Consumer equipment, Lighting equipment, Electrical and electronic tools, Toys, leisure and sports equipment, Medical devices, Monitoring and control instruments and Automatic dispensers. In 2008, the

Commission initiated a revision of the Directive as it had realised that there was room for improvements and simplification. With the revision of the Directive in 2011, the scope was extended to also cover all other electronic and electrical products not covered by these categories. Certain product groups are exempted from the Directive for instance equipment designed to be sent into space and transport means of goods and persons. Further, it is possible to apply for an exemption of a specific use of one of the restricted substances. The exemptions accepted so far are listed in Annex III of the Directive. (European Commission, 2011)

The aim of the Directive is to contribute to 'the protection of human health and the environment, including the environmentally sound recovery and disposal of waste EEE' (European Commission, 2011, Article 1). If electrical and electronic products do not comply with the regulation, the products are prohibited from being sold on the EU market (Europa, 2008). By prohibiting the use of certain hazardous chemicals, the Directive aims at changing the design of electrical and electronic products and facilitating the recovery of rare materials and substances in electronic products. In this way, the Directive aims at contributing to making the European Union more resource efficient in line with the Europe 2020 Strategy. (Europa, 2010)

In connection with the revision of the Directive, the Commission initiated an impact assessment for the Commission Proposal on the review of Directive 2002/95/EC. The aim of the impact assessment was to evaluate the proposals for improvement of the Directive. In Annex I of the impact assessment, the environmental benefits of the RoHS Directive are assessed. It is specified that the RoHS Directive has prevented several tonnes of hazardous substances from being present in electronic and electrical equipment. In the impact assessment, televisions are used to illustrate the effects of the RoHS Directive. In Table D, the effect of the RoHS Directive is illustrated by listing the amount of hazardous substances in one televisions before and after the RoHS Directive has entered into force. (European Commission, 2008)

*Table D-1: The content of hazardous substances of one television before and after the RoHS Directive has entered into force (European Commission, 2008, Annex I).*

| **Substance** | **Pre-RoHS** | **After RoHS** |
|---|---:|---:|
| Lead | 2131-5472 grams | 472-562 grams |
| Cadmium | 125 grams | 7-13 grams |
| Octa-BDE | 301-904 grams | 0 grams |
| Deca-BDE | 452-1597 grams | 0 grams |

Even though the RoHS Directive has achieved significant results the impact assessment notices that regarding the reductions of lead content is not the result of the RoHS Directive, but is a result of the technological development from cathode ray tubes to flat screens (European Commission, 2008, Annex I).

The impact assessment highlights that market surveillance activities have revealed a potentially high proportion of non-compliant electronic and electrical products. The non-compliance rate was up to 44% in one member state. Furthermore, it is underlined in the impact assessment that industry uses lead-free soldering in products not covered by the Directive in anticipation for the inclusion of these products in the scope of the Directive. (European Commission, 2008)

## D.2. WEEE Directive

The WEEE Directive sets marking requirements to producers and importers and aims at establishing an individual producer responsibility for the take back and treatment of WEEE. The latter makes the producer economically responsible for the take back and environmentally friendly treatment of WEEE. The producer can comply with this regulation individually or by joining collective schemes. The WEEE Directive also sets requirements for the recovery rates of the products in scope. (European Commission, 2012)

The first version of the Directive was adopted in 2003, and it has been revised three times since then, latest in 2012. Besides adopting stricter collection targets, the latest revision implies better tools to fight illegal export of waste and an improvement of the harmonisation of the national registration and reporting requirements (European Commission, 2014). The purpose of the Directive is*: to contribute to sustainable production and consumption by, as a first priority, the prevention of WEEE and, in addition, by the re-use, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste and to contribute to the efficient use of resources and the retrieval of valuable secondary raw materials. It also seeks to improve the environmental performance of all operators involved in the life cycle of EEE, e.g. producers, distributors and consumers and, in particular, those operators directly involved in the collection and treatment of WEEE.* (European Commission, 2012 preamble 6)

The idea behind the regulation is that by making the producer responsible for the end of life phase of their products, it gives economic incentives for the producer to integrate considerations about the product's end of life phase and recycling options in the design phase. In Article 4 of the Directive, it is stated; 'Member states shall, […] encourage cooperation between producers and recyclers and measures to promote the design and production of EEE, notably in view of facilitating re-use, dismantling and recovery of WEEE, its components and materials.' (European Commission, 2012, Article 4)

A study from 2010 has revealed that seven member states have fully implemented the individual producer responsibility and seven member states have ignored the implementation of the individual producer responsibility completely (van Rossem & Dalhammar, 2010). In the latter countries, the producers can join collective schemes, where they are not financially responsible for the take back of exactly their products, but the payments are based on averages. In these member states, the incentives for the environmental improvements of products have diminished significantly, and it is questionable whether the WEEE Directive fulfils its purpose on improvement of environmental performance at all.

The revision of the Directive in 2012 took into account these national deficiencies and the following is specifically added to the purpose of the Directive*:* 'In particular, different national applications of the 'producer responsibility' principle may lead to substantial disparities in the financial burden on economic operators. Having different national policies on the management of WEEE hampers the effectiveness of recycling policies. For that reason, the essential criteria should be laid down at the level of the Union and minimum standards for the treatment of WEEE should be developed'. (European Commission, 2012, preamble 6)

## D.3. REACH Regulation

The REACH Regulation entered into force on June 1$^{st}$ 2007. The Regulation concerns the Registration, Evaluation, Authorisation and Restriction of Chemical substances. The aim of the regulation is 'to ensure a high level of protection of human health and the environment' (European Commission, 2006: Article 1.1). This is ensured through an early identification of the properties of the chemical substances (European Commission, 2011b).

With the REACH Regulation, the industry is imposed the responsibility to identify and manage the risks related to the chemicals and to provide safety information on the substances. Manufacturers and importers are also required to gather information about the substances they import or produce and register this information in a central database, managed by the European Chemicals Agency (ECHA) in Finland. Furthermore, the Regulation ensures that the most dangerous chemicals is substituted when suitable alternatives are identified. (European Commission, 2011c)

In 2013, a review of the REACH Regulation was finalised. The report concluded that REACH functions well and delivers on all objectives, which are possible to assess. The first registration deadline was in 2010, and the industry met its obligations with 24,675 registration dossiers submitted. This corresponds to 4,300 substances, and the Commission emphasises that this implies that the data available for risk management has been significantly improved. (European Commission, 2013)

## D.4. Energy Labelling Directive

The first Energy Labelling Directive was adopted in 1992. The Directive sets a framework for mandatory energy labelling requirements for household appliances, such as refrigerators and washing machines. In 2010 a revision of the Directive was adopted which includes energy-related products in the scope (European Commission, 2010).

The scope of the Directive is ‘energy-related products which have a significant direct or indirect impact on the consumption of energy and, where relevant, on other essential resources during use’ (European Commission, 2010: Article 2.2). The aim of the Directive is (European Commission, 2010, preamble 5):

> ‘provision of accurate, relevant and comparable information on the specific energy consumption of energy-related products should influence the end-user’s choice in favour of those products which consume or indirectly result in consuming less energy and other essential resources during use, thus prompting manufacturers to take steps to reduce the consumption of energy and other essential resources of the products which they manufacture. It should also, indirectly, encourage the efficient use of these products in order to contribute to the EU’s 20 % energy efficiency target. In the absence of this information, the operation of market forces alone will fail to promote the rational use of energy and other essential resources for these products.’

As an example, televisions, which are placed on the European market, must be supplied with a label containing the following information (European Commission, 2010b):

1. the suppliers name or trade mark
2. the energy efficiency class
3. the on-mode power consumption and the annual on-mode energy consumption
4. the screen diagonal

The requirements of the Energy Labelling Directive are set up in implementing measures. In the case of televisions, the label focuses solely on energy efficiency in the use phase and the requirements are gradually tightened. 12 months after the publication of the implementing measure the most energy efficient label possible to obtain is A. From 2014, it will be possible to obtain the label A+ and the F will be the least efficient label. In 2017, A++ will be the most efficient label and E will be the least efficient label. Finally, in 2020, the most efficient label is A+++ and E will be the least efficient label. (European Commission, 2010c)

Since the adoption of the Energy Label in 1992, several evaluations of the achievements have been carried out. These evaluations show that there has been an increase in market share of the A and A+ labelled products since 1992 although there are differences between the different product groups and member states. The market share of appliances with the class A and B has increased from 10% in 1990-92 to around 57% in 1999 (Waide, 2001). In Figure 38 and Figure 39, the Danish sales figures for washing machines and refrigerators divided on energy classes are illustrated. This also shows an increase in market share for appliances with the higher energy classes. For some product groups, a unilateral agreement was made within CECED (the European Committee of Domestic Equipment Manufacturers) to stop producing the products with the lowest Energy Label ratings. The product groups covered were among others refrigerators, freezers, dishwashers and washing machines and the agreement has encouraged the development of more energy efficient appliances. (Waide, 2001; Schlomann et al., 2001; Bertoldi & Atanasiu, 2007; Bundgaard, Zacho & Remmen, 2013)

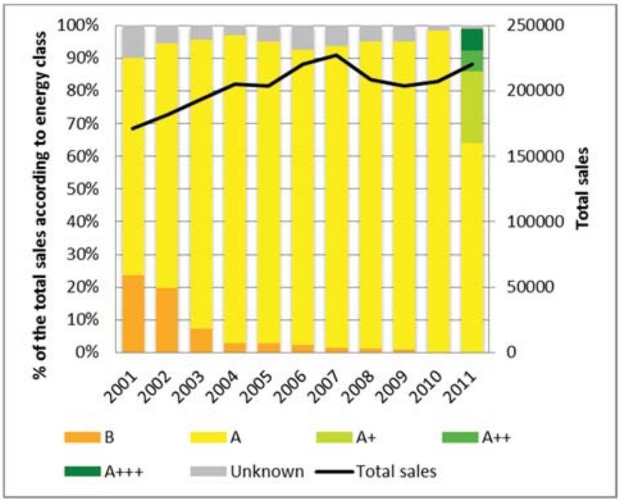


*Figure 38: Total sales of washing machines in Denmark 2001-2011 (the black line) and the percentage distribution of the total sales according to energy class (bar chart). (FEHA, 2012; Bundgaard, Zacho & Remmen, 2013).*

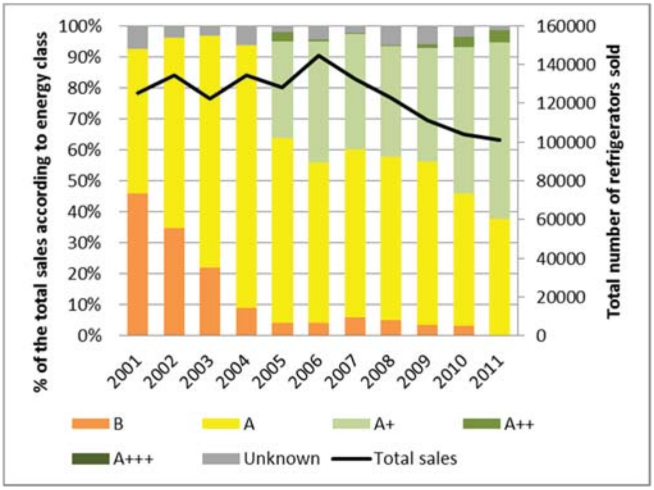


*Figure 39: Total sales of refrigerators in Denmark 2001-2011 (the black line) and the percentage distribution of the total sales according to energy class (bar chart). (FEHA 2012; Bundgaard, Zacho and Remmen 2013).*

In 2014, an evaluation study of the Energy Labelling Directive and certain aspects of the Ecodesign Directive was finalised. The study emphasises that the Energy Labelling Directive together with the Ecodesign Directive are able to generate substantial savings cost-effectively, and the expectations are 6700$PJ_{prim}$ per year in 2020 concerning al regulations that are or are close to finalised by April 2014. This equals 19% savings compared to business as usual. In addition, the study among other things highlights that there is a reduced effectiveness of labels following introduction of A+ and up classes and that the energy saving potential of taking a system approach should be investigated further. (Molenbroek et al., 2014)

## D.5. European Ecolabel

The European Ecolabel was established in 1992. A large range of products can be awarded the Ecolabel from campsite services to paint and refrigerators. The European Ecolabel 'is intended to promote those products which have a high level of environmental performance through the use of the European Ecolabel.' (European Commission, 2010d, preamble 5)

In this section, the requirements for televisions are presented. The Commission Decision establishing the revised ecological criteria for the award of the Community Ecolabel to televisions was published in March 2009 and focuses on the following areas (European Commission, 2009):

- Power consumption in on-mode

- Power consumption in standby
- Maximum energy consumption
- Dismantling
- Life-time extension
- Chemicals in products
- Information requirements

From the above list, it is clear that the European Ecolabel sets requirements to several of the products life cycle; these are the design phase, the use phase and the end of life phase. In addition, several environmental impact categories are addressed.

Since the introduction of the label, the number of labelled products and services has grown steadily. By December 2010, 1152 licences were awarded; nine of these were awarded televisions. (European Commission, 2011d)

## D.6. Green Public Procurement

Green Public Procurement (GPP) is defined as ‘a process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured.’ (European Commission, 2008b)

The aim of GPP is to use the purchasing power of the European public authorities to influence the production and consumption trends. The public authorities in the European Union (EU) spend the equivalent of 16% of the EU Gross Domestic Product each year on purchasing goods (European Commission, 2008b: p. 2). By increasing the demand for green products, the aim is to stimulate innovation of green technologies and the production of greener products. (European Commission, 2008b)

GPP is a voluntary instrument and hence the extent of the implementation of GPP is decided by the individual EU member state. The Commission provides guidance and tools to promote GPP in the members states. Common GPP criteria has been developed for 18 different sectors, the newest were available in July 2010. Sectors covered by the criteria are among others copying and graphic paper, cleaning products and services, windows, glazed doors and skylights and thermal insulations. (European Commission, 2011e, 2011f)

The GPP criteria are developed according to several principles. The GPP criteria must among others (European Commission, 2011f):

- *Take into consideration the net environmental balance between the environmental benefits and burdens, including health and safety aspects;*

*where appropriate, social and ethical aspects will be considered, e.g. by making reference to related international conventions and agreements such as relevant ILO standards and codes of conduct.*

- *Be based on the most significant environmental impacts of the product, be expressed as far as reasonably possible via technical key environmental performance indicators of the product, and be easily verifiable.*
- *Be based on life cycle data and quantitative environmental impacts, where applicable in compliance with the European Reference Life Cycle Data Systems (ELCD).*

From the above principles, it appears that when developing GPP criteria the entire life cycle of the products must be taken into consideration. However, as the criteria should be based solely on the most significant environmental impacts it is not definite that the criteria include requirements on the entire life cycle of the product.

In 2006, a voluntary target for GPP was set in the Sustainable Development Strategy. The target was that by 2010 an EU average level of GPP should be equal to that currently achieved by the best performing Member States (Council of the European Union, 2006). In 2008, the European Commission proposed that 50% of all public tendering procedures should be ‘green’ in 2010 (European Commission, 2008b). A study from 2009 revealed that the seven best performing Member States on average included environmental considerations in 55% of the total procurement contracts, corresponding to 45% of the procurement value. The study concerned the year 2006/07 and covered ten GPP priority sectors. (PricewaterhouseCoopers, Significant & Ecofys, 2009)

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# Appendix E. The Conceptual Framework in Chapter 8

An overview of how the conceptual framework, which is developed in section 8.5, is related to the frameworks presented in Chapter 8 is presented in this appendix. The frameworks presented in Chapter 8 are the Corporate Social Responsibility as Shared Value framework, the 3-Stage Framework for Innovating for Business Sustainability, the Stages of Corporate Citizenship and LCM Capability Model. In Table E-1, an overview is given of how the four levels of sustainability strategies in the conceptual framework relate to the frameworks presented in Chapter 8, while in Table E-2, an overview is given of how the parameters in the conceptual framework relate to the frameworks presented in Chapter 8.

*Table E-1: How the four levels of sustainability strategies relate to the frameworks presented in Chapter 8.*

<table>
<tr><th></th><th>Ad hoc</th><th>Operational optimisation</th><th>Organisational transformation</th><th>Systems building</th></tr>
<tr><td>Sustainability concept</td><td rowspan="6">Taken from the LCM Capability model.<br><br>This level is related to Stage 1 Elementary in the Stages of Corporate Citizenship framework.</td><td rowspan="6">Taken from the 3-Stage Framework for Innovating for Business Sustainability<br><br>This level is related to Stage 2 Engaged in the Stages of Corporate Citizenship framework, and Level 3 Efficient in the LCM Capability model.</td><td rowspan="6">Taken from the 3-Stage Framework for Innovating for Business Sustainability<br><br>This level is related to Stage 3 Innovative in the Stages of Corporate Citizenship framework, and Level 4 Effective in the LCM Capability model.</td><td rowspan="6">Taken from the 3-Stage Framework for Innovating for Business Sustainability<br><br>This level is related to Stage 5 Transforming in the Stages of Corporate Citizenship framework, and Level 5 Adaptive in the LCM Capability model.</td></tr>
<tr><td>Strategic intent</td></tr>
<tr><td>Structure</td></tr>
<tr><td>Span of influence</td></tr>
<tr><td>Stakeholder relations</td></tr>
<tr><td>Transparency</td></tr>
</table>

*Table E-2: How the parameters relate to the frameworks presented in Chapter 8.*

<table>
<tr><th></th><th>Ad hoc</th><th>Operational optimisation</th><th>Organisational transformation</th><th>Systems building</th></tr>
<tr><td>Sustainability concept</td><td colspan="4">Taken from the Stages of Corporate Citizenship framework, where it is called Citizenship concept.<br><br>The parameter is, however, also related to the parameters named Innovation outcome and Innovation objective in the 3-Stage Framework for Innovating for Business Sustainability and the parameters Business case and Span of influence in the LCM capability model.</td></tr>
<tr><td>Strategic intent</td><td colspan="4">Taken from the Stages of Corporate Citizenship framework.<br><br>The parameter is, however, also related to the parameters named Innovation outcome and Innovation objective in the 3-Stage Framework for Innovating for Business Sustainability and the parameters Business case, metrics and Span of influence in the LCM capability model.</td></tr>
<tr><td>Structure</td><td colspan="4">Taken from the Stages of Corporate Citizenship framework.<br><br>The parameter is, however, also related to the parameter Description in the LCM capability model.</td></tr>
<tr><td>Span of influence</td><td colspan="4">Taken from the LCM capability model.<br><br>The parameter is also related to the parameters Innovation objective from the 3-Stage Framework for Innovating for Business Sustainability and the parameters Citizenship concept and Strategic intent in the Stages of Corporate Citizenship framework.</td></tr>
<tr><td>Stakeholder relations</td><td colspan="4">Taken from the Stages of Corporate Citizenship framework.<br><br>The parameter is also related to the parameter Innovation objective in the 3-Stage Framework for Innovating for Business Sustainability.</td></tr>
<tr><td>Transparency</td><td colspan="4">Taken from the Stages of Corporate Citizenship framework</td></tr>
</table>


## SUMMARY

This PhD thesis is about the Ecodesign Directive and how companies apply ecodesign. The analyses shows that the Ecodesign Directive provides a framework for setting comprehensive ecodesign requirements, but the implementation of the Ecodesign Directive entails a unilateral focus on energy in the use phase. The case study of televisions shows that the ambition of the minimum requirements is relatively low and ecodesign efforts are driven by technological development rather than the Ecodesign Directive. The analysis of the case companies shows that Grundfos has a high ambition level whereas Bang & Olufsen's and Danfoss Power Electronic's sustainability strategies include sustainability to some degree. Despite different strategies towards sustainability, the employees are facing similar challenges when working with sustainability, for example that the organisational structure is not yet in line with the ambition level. On the operational level, the analysis shows that the companies' business strategy is a major driver and barrier for practicing ecodesign in the companies. In the product development, the product concept specification and product requirement specification are determining the approach to ecodesign. The Ecodesign Directive influences the companies no matter at what strategic level they are working with sustainability.

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